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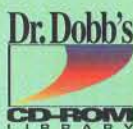
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Programming Jobs: What, Where, and How Much?

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RESOURCE CENTER

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The Programmer Shortage:

Fact or Fiction?

When I was in college, I invited Francis Corbett, an engineer who had analyzed photographs and home movies of JFK's assassination, to give a talk on image-analysis algorithms to our computer club. As it happened, a bunch of rowdy nonstudents who believed JFK's assassination was a conspiracy showed up to the lecture. Corbett, fortunately, had dealt with hecklers before, and was handling the situation much better than I. Luckily, the lecture was also attended by some exceptionally large and well-mannered folks who quieted down the rowdies so that Corbett could finish his talk.

I learned a couple of important lessons that day—none of which had anything to do with image processing. The first was to never, ever sponsor a public lecture that has anything to do with JFK's assassination. The second was that physical intimidation can have a remarkable calming effect on people. To this day, I owe those big hairy guys with the leather jackets a debt of gratitude.

Programmer Shortage: A Conspiracy?

It's easy to laugh at conspiracy theorists (unless, of course, they're physically present and outnumber you). But it's hard to deny that for every conspiracy theory, there's often a grain of truth. Most of the time, that grain is insignificant, but sometimes, it's impossible to ignore. And when you strip away the inevitable name-calling and hysterical references to Communists, paparazzi, and Bill Gates, you are left with some facts that can get you thinking.

On February 25, 1997, for instance, the Information Technology Association of America (ITAA) released a report entitled, "Help Wanted: The Information Technology Workforce Gap at the Dawn of a New Century." The message was straightforward: We're running out of skilled technology workers, and this will adversely affect our economy. Our society's growing reliance on software, the report claimed, was creating a greater demand for software professionals. The report went on to state that our educational system was not meeting this demand.

Business journalists at the time must have been bored by all of the positive news about our better-than-ever economy, because the report managed to seep into the headlines of several major newspapers and magazines. Software, after all, had become the nation's third-largest manufacturing industry with wages twice the national average, and the software industry was growing over twice as fast as the rest of the economy. If programmers couldn't meet the demands of the software industry, then the economy was in serious trouble.

If you're a programmer, of course, you're thrilled by the report—it means higher wages, more incentives, and even societal status. And there's no reason to believe it isn't true. After all, what does the ITAA (or anyone else, for that matter) have to gain from creating a programming shortage out of thin air?

For starters, aliens—not the kind from outer space, but the kind from other countries. Immigrants tend to accept lower wages than U.S. citizens for equivalent jobs, hence their attractiveness to large ITAA-member companies wanting to increase profit margins. The ITAA report suggests that non-U.S. workers might be one of the solutions to the shored up demand. Indeed, in his paper "Debunking the Myth of a Software Labor Shortage," Norman Matloff, a professor of computer science at the University of California at Davis, cites a *San Jose Mercury News* article (November 21, 1997) where "the ITAA stated that its 'num-

ber one priority' would be to increase the yearly quota of H-1B work visas."

Additionally, Matloff points out that there are indeed engineers who could easily fill the current positions. These are the same engineers who were downsized in the late '80s and early '90s, and who may not even be in the tech industry currently, which is why they wouldn't be accounted for in the supply numbers. However, because older and more-experienced engineers command higher salaries, Matloff argues that companies would rather spend training money on cheaper immigrants and students coming out of college.

There was more fodder for conspiracy theorists in the ITAA study. The report noted that undergraduate computer-science degrees awarded by U.S. universities declined 42 percent between 1986 and 1994. What it didn't say was that the trend reversed itself in 1995, and enrollment was significantly higher in 1996. The Computing Research Association, a national consortium of university computer-science departments that released this study, had, according to Matloff, brought this study to the ITAA's attention before the final version of the report was released. However, these statistics garnered no mention.

Other Reports Also Claim Shortage

The ITAA undoubtedly has its own reasons for hyping its study on the programmer shortage. But it's important to remember that the report also emphasized the need to improve the educational system, to encourage students to pursue a high-tech career, and for greater corporate philanthropy. When ITAA president Harris Miller testified in front of the Senate Committee On Labor And Human Resources in April, 1997, he did not even mention immigration, focusing instead on the need for improved education. And at the ITAA-sponsored National Information Technology Workforce Convocation in January, 1998, topics on the agenda included basic math and science competencies, and recruitment of minority groups—hiring non-U.S. workers was not on the agenda.

(Curiously, at the same convocation, Matloff was invited to present the programmer shortage issue. Matloff's talk was not on the original agenda, and was placed on the program only at the insistence of the House of Representatives Commerce Committee, who wanted the conference opened to other viewpoints. But the press was noticeably absent from Matloff's talk. The ITAA had bused most of the press across town to attend a press conference scheduled at the same time as Matloff's presentation. Miller called the suggestion that this was an ITAA conspiracy "nutty.")

The reports released by the Stanford Computer Industry Project (SCIP), one of which is published in this issue, may be part of the reason that the proposal for looser immigration laws has not been emphasized in the context of the programmer shortage debate. SCIP, while reinforcing the notion that foreign countries are a good source for temporarily plugging the gap, concluded that, in the long term, the programmer-shortage problem is global. The entire world, not just the U.S., is suffering from a shortage of programmers. While SCIP endorsed using non-U.S. programmers as an immediate solution for meeting demand, it felt the solution was only temporary and limited in its effectiveness.

SCIP addressed other deficiencies of the ITAA report. In a recent *New York Times* article, Shirley Tessler, one of the coauthors of the SCIP report, argued that the recent upswing in computer-science enrollment was not encouraging. Tessler stated that many

of those students would drop out, and many were non-U.S. students who would return to their native countries upon graduation.

Most recently, the Department of Commerce's Office of Technology Policy (OTP) released a report entitled, "America's New Deficit: The Shortage of Information Technology Workers." While not releasing any new data—it reported the results of several different studies, including the ITAA and SCIP studies—the OTP was fairly rigorous in its analysis.

The OTP report made the important point that in all of the various studies, the term "IT worker" had different meanings. For example, the ITAA report defined IT workers as those who study, develop, implement, support, or manage computer-based information systems, a mighty broad definition that would include computer scientists, programmers, testers, customer support, system administrators, and others. The OTP report offered four categories of IT workers: computer scientists, computer engineers, systems analysts, and computer programmers. The OTP report also pointed out that most of the studies' projections did not take into account IT workers who did not have a formal computer-science background.

So Is There a Shortage?

Cries of impending labor shortages in high-tech fields are nothing new. Longtime fans of "The Andy Griffith Show" know that phones didn't always have buttons or even dials. Calls were made by picking up the receiver and asking the operator to call a particular location. While suitable for Mayberry, systems like this weren't very scalable. It was predicted that under this system, there would eventually have to be one telephone operator per person. In 1916, at a Bell Systems Technical Conference, managers discussed the "difficulty of securing and retaining an adequate number of operators." The telephone company was worried that wages were high and the supply of "qualified" operators were low.

Three years later, AT&T adopted automatic switching in large cities. The eventual total adoption of automatic switching essentially converted everybody into his or her own telephone operator, thus providing the necessary supply and averting the predicted communication crisis. As quickly as the cries of paranoia had started, telephone operators were suddenly out of a job.

Similarly, in the early 1960s, projections suggested that everybody would have to become a computer programmer in order to meet the expected demand. The government poured money into educational and training programs in response. Once again, however, advances in technology—compilers, cheaper and faster computers for the masses, structured and object-oriented programming—slowed the demand curve to the point where, by the 1980s, people believed that the market for programmers was saturated.

Robert Rivers, chair of the American Engineering Association's Manpower committee, points out that in a market economy, long-term shortages cannot exist. However, this is only true if the supply of workers is elastic.

This is the defining question. Those who believe that the supply of IT workers is elastic believe that, in our free market, rising salaries are enough of an incentive to encourage people to enter the field. Those who believe that the shortage is a real, long-term problem, believe that IT workers are not commodities, that only a special subset of society is qualified to become an IT worker, and that other things are needed to address this impending shortage.

The past seems to indicate that the supply of high-tech workers is elastic, and the demand, cyclical. But Tessler disagrees, stating in a recent *EE Times* article (April 7, 1997), "This is different. It transcends all industries. I don't see the need for software as cyclical at all. I see strong, steady growth."

Why the Demand?

The more important question is not why is supply so low, but why is demand so high? Clearly, technology pervades our society more than it ever has. Was this simply a well-defined trend from the beginning that we all just ignored until now?

Embedded-systems development has created some of this demand, but I don't think this the main cause. True, microprocessors are rapidly replacing specialized hardware, but it's likely that engineers can transition from drawing schematics to writing code.

Consumer software companies are not likely to be the problem either. The consumer software industry has proven itself to be extremely fickle over the years—companies that dominate the market and the public eye often quickly fade away, only to be replaced by new companies—and there's no reason to believe that this will change.

Most likely, the biggest cause of this growing demand are large corporations spending billions of dollars a year on IT, based largely on the belief that throwing money at technology will improve productivity and profits. Economists and businessmen, such as Thomas Landauer and Paul Strassman have disputed such practices, showing that many organizations have thrown away millions of dollars as a result of this belief. In a wicked twist of irony, the U.S. government recently announced it will spend \$28 million to help train and place competent IT workers, of which \$8 million will be spent on a web site for job announcements. In other words, the government is devoting nearly a third of its investment to an IT project that, by creating more IT demand, may actually contribute to the very problem it is trying to address. Niccolo Machiavelli was prescient when he observed that one need not look for conspiracy if incompetence can explain most mishaps.

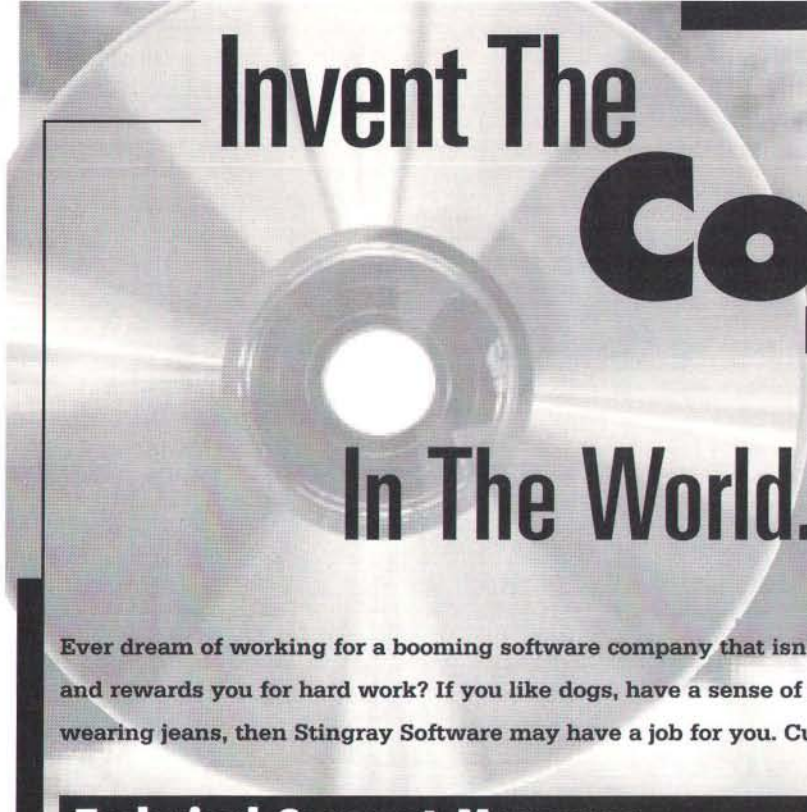
Corporations (and maybe even the government) may eventually wise up, and these and other inefficiencies in the system might go away. Lower and better-managed spending could decrease the current demand for IT workers. But it's impossible to know for sure whether or not new inefficiencies and promises of a better technological future will create new demands to replace these current ones.

Back To The Real World

What the future holds for IT worker—and professional programmers, in particular—is unclear. What is clear is that the demand for programmers is high right now, and the pay is good. If you keep your skills honed and your mind open, you'll be gainfully employed in the future, programmer shortage or not. And that's no conspiracy.



Eugene Eric Kim
technical editor



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Programming Jobs: What, Where, and

Demand is outstripping supply



Instead of worrying about finding a job, the biggest problem most people entering computing careers will face may be choosing from among a throng of opportunities.

According to the Bureau of Labor Statistics, the computer and data-processing service industry tops the employment chart in projected growth through the year 2006. In 1996, the Bureau calculated that there were 1,208,000 computer-related jobs in the nation—a number expected to increase by about 108 percent to 2,509,000 over the next nine years. To fully grasp the magnitude of this growing demand, note that the same study found that the second-fastest growing industry (health services) could expect a job-demand increase of 68 percent over the same time period.

A recently released study by the Information Technology Association of America (ITAA) and Virginia Polytechnic Institute (Virginia Tech) predicts that IT worker shortages will be even more severe over the coming years. According to ITAA/Virginia Tech findings, the current “core” IT workforce—programmers, systems analysts, and computer engineers—is about 3,354,000. Approximately 10 percent, or 346,000, of positions are open today. This is a significant difference from the ITAA’s 1997 IT worker study, which showed 190,000 IT vacancies a year ago. Furthermore, the 1998 study indicates that shortages exist throughout the U.S., with comparable vacancy rates across geographic regions.

Deirdre Blake

How Much?



"Whether we are talking about the programmers and systems analysts who develop IT products and services or the business and technical personnel who must use IT effectively, our findings speak for themselves. IT worker shortages continue to be a national crisis today and into the foreseeable future," said ITAA president, Harris N. Miller.

Bolstering the ITAA and the Bureau's findings is a recent examination of the high-tech job market in the Washington, D.C. area by *The Washington Post*. According to *The Post*, an estimated 25,000 technology jobs were going unfilled due to a shortage of skilled workers. Among the most highly sought employees, said *The Post*, are those experienced in database programming (particularly those familiar with Oracle products) and C++ programmers. And the number of vacancies is only expected to rise. The employment forecast is similar throughout the country.

Mirroring the *Washington Post* findings, for instance, Robert Half International, a nationwide provider of staffing services and employment resources, predicted in its 1998 Salary Guide that the IT labor demand will continue to soar with several skill sets standing out among the IT specialties in highest demand: networking specialists, including client/server architects, network support technicians, and network administrators; relational database specialists, where again those with experience in Oracle database development and administration are especially sought; Internet/intranet professionals, including those skilled in CGI, HTML, and Java programming; help desk support professionals, particularly those with trouble-shooting talents and training abilities; and legacy system specialists for work on mainframes in ongoing attempts to address Year 2000 computing problems.

Salaries for high-tech professionals are also rising steadily. According to "Cyberstates," a report on the U.S. electronics and IT industry prepared by the American Electronics Association (AEA), the average high-tech worker enjoyed a 10.4 percent salary increase between 1990 and 1995—software and computer service workers, in particular, saw a slightly higher increase in salary overall during the same time frame. The AEA reported that, in 1995, the average wage for a high-tech worker in Washington state was over \$57,000 per annum—more than twice the average private sector wage in the state at the time. Though Washington led the nation in high-tech salaries at the time of the study, other states reported similarly large gaps between the average high-tech wage and the average overall wage due to the expansion of the industry and the increased need for skilled workers. For example, in Tennessee (which ranks 25th among the states in IT employment), the average high-tech wage in 1995 was \$36,619, when the average private sector wage was \$24,749.

With such high demand for computing professionals, companies are offering incentives in addition to large salaries to attract and retain workers. For example, the *Austin Business Journal* reports that companies facing high-tech labor shortages were increasingly offering such benefits as signing bonuses and third-party housing arrangements. Other hiring incentive trends include stock options and stock grants, day care for employees' children, fitness club memberships/on-site fitness centers, and company cars.

Although often lacking in experience, recent college graduates won't lack in opportunities. According to the National Association of Colleges and Employers (<http://www.jobweb.org/nace/>) hiring of 1998 college grads will increase 19.1 percent overall this year. With the unemployment rate at a 24-year low, nearly five percent of the 1998 graduates will fill jobs that historically have gone to more-experienced workers.

"Some of the respondents told us that they would prefer to hire experienced workers, but can't find any," said Marilyn Mackes, NACE executive director. "As a result, they are turning to the college market to fill their needs."

Starting salaries for graduates with a bachelor's degree is expected to increase more than 4.5 percent over previous years. According to NACE, computer-science graduates can expect to be offered an average starting salary of about \$38,475 (up over six percent from last year's starting salaries), while computer engineering graduates can expect an average starting salary of \$39,593. (In comparison, liberal arts grads can expect an average starting salary of about \$29,000.)

The annual NACE survey also found that the Internet is increasingly being used as a hiring tool. "Employers are using a variety of methods to find the new graduates they need," Mackes went on to say. "Last year, posting jobs on the Internet was near the bottom of the list in terms of usage; this year we saw a healthy increase in its use. Employers are warming up to online recruiting as a nice addition to the more traditional methods they use to hire new college graduates, such as job and career fairs and employee referrals." In 1997, employers gave Internet job postings a rating of 2.65; this year, the rating was 3.13. (Ratings are based on a five-point scale; one = never use; five = always use.)

Wrapping It Up

Anyway you look at it, the time is ripe for computing professionals to reap great rewards for their talents. For a closer look, examine the regional snapshots on high-tech employment we present here.

Deirdre is managing editor of Dr. Dobb's Journal. She can be contacted at dblake@mfi.com.

"It's a Skills Shortage"

Peter Behr

A shortage of technology workers has become the biggest single obstacle to continued economic growth in the greater Washington D.C. region. According to two separate surveys, there were about 20,000 tech job vacancies in Northern Virginia early this year and analysts believe another 5000 to 10,000 vacancies exist in suburban Maryland's technology corridors and, to a lesser degree, in the District of Columbia. To some extent these figures are inflated by the competition among tech companies for workers, employment analysts say. Some survey respondents are undoubtedly describing vacancies they would like to fill if they could get the contracts and orders they're seeking. And some of the vacancies follow from the very high rates of churn within the technology sector. But no one close to the issue quarrels with the premise that tech workers are scarce and growing scarcer—posing a threat to the region's economy.

Programming skills are in greatest demand, although the 20,000 vacancies fig-

ure is based on a broad definition of tech jobs by researchers at George Mason University in Fairfax that includes both people who create tech products and services and those who use them to a large degree in their work.

The demand is fed by the rapid expansion of the region's technology contractors and consultants who are seeking a piece of government information technology outsourcing and by the growth of a smaller but more vibrant cluster of Internet services companies in the region. Industry analysts estimate that about 40 percent of the \$20-billion-plus information technology services and products provided annually to federal agencies goes to contractors along the Capital Beltway. The need for telecommunications networkers and wireless technicians is also great because of the concentration of telecom services companies in the region.

In a recent series of articles about the tech worker shortage, *The Washington Post* reported that programmers skilled in Oracle software, C++, and Java were in greatest demand in the area. (An analysis by Jungle Corp. of Sunnyvale, California of 628 computer employment opportunity ads in

The Post on a typical Sunday this fall found that 21 percent wanted Oracle programmers, 20 percent called for C++, and 9 percent wanted Java skills.) Visual Basic experience is another hot skill.

The urgent need to fix the federal government's extensive "Year 2000" software problem has created a demand for Cobol and Fortran programmers as well.

But the skills themselves often are just a starting point. Generally, employers covet programmers with experience in specialized applications, employment managers say. "They have very unique requirements," said Chris Dunne, a senior account manager at Consortium Inc., a technology recruiting firm in Bethesda, Maryland, in an interview with *The Post*. Federal agencies often aggravate the situation by specifying particular skills and experience requirements, blocking employers from using talented programmers who fall short of these requirements.

In short, the situation is more accurately called a "skills shortage" than a "tech worker shortage." That distinction is most obvious in the ever-present tech job fairs going on around the region. It's common for tech companies to pay a

Computing in Kansas City

Toni Cardarella

Kansas City, Missouri, area companies are scrambling to hire programmers, creating a competitive market for new college graduates, and the demand is expected to continue for the next five years. The area is home to a couple dozen large corporations, including Hallmark Cards, DST Systems, Yellow Freight, and Blue Cross/Blue Shield, each with information technology divisions that employ 400 to 500 programmers.

"The big companies are all in need to replenish what they're losing or to help them grow," says George Waterman, who owns a Kansas City-area employment agency that specializes in placing programmers.

Locally based solution companies, such as Cerner Corp. and Informix Software, need programmers as well. At one recent college job fair in the Kansas City area, there were more than 125 companies recruiting from a pool of less than 100 graduates, according to Scott Biggerstaff, Cerner's senior technical recruiter.

As in other areas of the country, the shortage in Kansas City can be attributed, in part, to the date change-over in the year 2000, which calls for more people trained in the legacy main-

frame systems. There is a temporary shortage it seems for programmers who are familiar with old technology, particularly Cobol. The advent of new technology and a decreased number of information technology graduates is continuing to up the demand for object-trained and network graduates.

"Internet and intranet are especially hot right now," says Don Weiss, president of Step 1, a professional programmer training company based in the Kansas City suburb, Overland Park, Kansas. Many companies are desperate to put a browser interface on legacy systems, and skills in Java, database programming, and general Internet knowledge are very valuable for these projects.

In the Kansas City area, annual salaries for entry-level programmers range begin around \$25,000 to \$32,000 and go as high as \$48,000 to \$50,000, depending on the size of the company, and the quality of the college, and grades of the graduate.

Toni is a Kansas City freelance writer who specializes in business- and employment-related issues. She can be contacted at tcadar@aol.com.





Washington D.C.

\$3000 registration fee, interview 50 to 100 applicants in a two-day fair, wind up hiring one or two new people—and consider the tech fair a success!

There is only anecdotal information on tech worker salaries in the Washington area although employers say that salary levels described in Coopers & Lybrand's national surveys apply here as well. Computer science graduates from top area universities like Virginia Tech are being hired for \$45,000 plus and the salaries move up from there. The breadth of the shortage is illustrated by an executive of Merchants Inc., the tire and auto repair chain, who said that starting salaries for automotive technicians range from \$30,000 to \$50,000. Master technicians, with six years of technology education, can make as much as \$100,000 a year, he said.

Bonuses of \$5000 to \$10,000 have been paid to get skilled tech workers to jump to a new employer. Stock options are another important inducement, giving younger start-up firms an advantage over the larger, established Beltway systems integrators and consulting shops whose stocks aren't volatile. SRA International Inc., an Arlington, Virginia, computer systems

company, has paid its employees \$10,000 per head for referring successful recruits to the company.

The shortage is already causing some fundamental changes in the way technology is taught. Community colleges are increasing their offerings of one-year certificates for successful completion of a cluster of computer courses requested by employers. One local technology college is offering extensive interactive classes over the Internet. Business and education leaders will ask state legislators in Annapolis to fund a doubling of engineering and computer science enrollments over the next five years. The goal sought by Virginia leaders is more ambitious—a tripling of science graduates. And Maryland's governor will propose that the state provide free tuition to the state's high school graduates who study high-demand technology courses in Maryland universities and then agree to work for Maryland companies for two to four years after leaving school.

Some region leaders are calling, additionally, for a far greater effort by tech companies to train and retrain their current workforce—perhaps with training opportunities linked to commitments by

workers to stay with their employer for a certain period of time after the training is done.

There is also a need to give clear, unbiased counseling about tech education to workers seeking to shift into technology careers, some experts say. While tech training courses are proliferating at colleges, for-profit training schools and industry "academies," the quality of these programs varies widely, experts say, hence the need for guidance about the skills industry require of new hires. A pilot program at Northern Virginia Community College will begin this year to offer such counseling.

"The key economic assets in this region are based on human capital, not machines and equipment," said Robert Stough, director of regional analysis at George Mason University in an interview with *The Washington Post*. "If we can't find better ways to compete for workers, or train them better, we run the risk of missing the boat."

Peter is a business reporter for The Washington Post and can be contacted at behrp@washpost.com.

Seattle: Beyond Microsoft

Thomas W. Haines

The debate in Seattle these days is not whether the economy is booming, but how long it will stay that way. Fueled by growth at Boeing and Microsoft, the Puget Sound region has generated roughly twice as many new jobs over the past year as other parts of the nation. And nowhere, experts say, is the growth in Seattle as pronounced as in the software industry.

Of course, nearby Redmond and Microsoft set the tone. The company again projects to hire as many as 2000 employees for all manner of positions over the next year. But others, from corporate giants such as Safeco and Boeing, to Internet startups and web-design firms, promise to keep demand high. Intel, which opened a plant

in the town of Dupont in 1996, is continuing to staff up toward a projected total of more than 6000 employees.

Around here, career decisions for qualified software engineers are measured by the number of job offers in hand. Senior people are known to skip around the Internet firms of downtown Seattle the way colleagues meander companies sprinkled through California's Silicon Valley. Stock options are common. And, according to at least one survey, pay is high.

Companies large and small advertise for an array of technical skills, including experience with C, C++, Visual Basic, Pascal, SQL, Java, and ActiveX.

A report issued this year by the American Electronics Association determined Washington state's high-tech workers get paid, on average, more than anywhere else

in the nation. Washington's average pay: \$57,555 a year. The report noted that the figure is higher than other areas because most high-tech jobs here are in the software side, rather than manufacturing.

The number of high-tech jobs in the state is also growing, according to the study. Between 1990 and 1995, the state added 18,516 jobs for a total of 78,920, a 30 percent increase. Of those jobs, 29,600 are in software and computer services; 21,500 in telecommunications services. One local forecast predicts the growth trend will continue, with more than 3000 computer-related jobs added next year. Overall, though, the number of jobs here still trails other developed tech centers, including Silicon Valley, Texas, and Massachusetts. The state of Washington ranks 18th in total high-tech employment.

Thomas covers technology for The Seattle Times and can be contacted at thai-new@seattimes.com.



Seattle

Utah: More than Just Mountains

Lisa Carricaburu

In Utah's fast-growing information-technology (IT) industry, people capable of writing code are so scarce that those who can are able to write their own job descriptions and salary profiles.

In fact, Salt Lake County government's IT operation has experienced such difficulty recruiting and retaining qualified programmers and systems administrators that the County Commission recently considered drafting a policy that would require new hires to commit to their jobs for two years.

Unable to fill numerous openings for web developers and other programmers at a planned microchip-testing facility in Lehi, Micron Technology human resources manager Brad Mabe staffed an exhibit at COMDEX/Fall in Las Vegas for the express purpose of recruiting potential hires from outside Utah.

"We are hiring programmers as quickly as we can find them," said Kathi Teigeler Alder, director of sales and marketing for Vitrex, an Ogden-based software and network consulting firm. "The scarcity of human resources is the one thing that can limit our growth."

Like many Utah IT firms, Vitrex consistently has openings for AS400/RSG, Cobol, Oracle, and C++ programmers—positions for which the company's salaries vary with experience but are in the \$60,000 range.

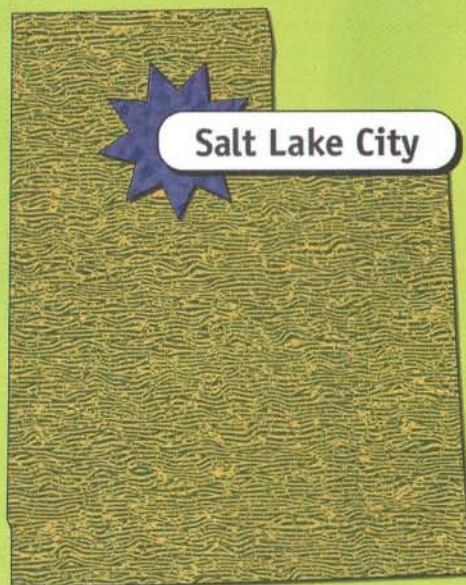
"Like everyone else, we have to pay top wages and good benefits to recruit and retain people," she said.

Overall, unemployment in Utah is lower than it has been in more than four decades. The state's jobless rate for all of 1997 likely will be 3.2 percent, a low the

state has not experienced since 1952, said Ken Jensen, Utah Department of Workforce Services (DWS) chief economist.

Bolstered by small enterprises as well as by large firms such as Provo's Novell and Roy's Iomega, the IT industry is among the state's best new job producers, said Peter Genereaux, Utah Information Technologies Association (UITA) CEO.

UITA counts 1870 IT firms in Utah employing 38,971 workers. The organization's annual survey of the industry shows employment increased 12 percent from 1995 to 1996.



In addition, the UITA survey predicts 50 percent job growth in the industry in the next three years, with employers saying the job positions that promise the greatest growth are hardware and software development, customer support and systems development, operations and maintenance.

More immediately, Genereaux said many Utah firms work on Year 2000 problem fixes, and are desperate for Cobol programmers. Oracle, C++, Visual Basic, and Java programmers also are in high demand, as are certified Novell NetWare and Microsoft Windows NT professionals.

"Some qualified Oracle programmers are commanding salaries in excess of \$100,000," he said.

IT professionals are among the best-paid workers in Utah.

U.S. Department of Labor data for the Salt Lake/Ogden area, for example, puts the average hourly wage for programmers at \$17.00 and the average hourly wage for systems administrators at \$25.00, said John Mathews, a DWS labor-market economist.

UITA figures show Utah's overall average wage at \$23,628 in 1996 compared to \$38,724 for IT professionals. The highest-paid positions, Genereaux said, are in the areas of software development and programming and in sales and marketing.

And salaries will only increase with the labor shortage, he said. That presents a particular challenge for businesses outside the sector, which often do not have the resources to pay the wages qualified workers command.

The challenge has led to a number of government initiatives.

The Utah Information Technology Commission, for example, has sent letters to the state's universities and technical training centers asking for help to enlarge the pool of job candidates. The group also is asking the Legislature for \$1 million to boost salaries paid to IT workers. "It's a serious problem that we're all trying hard to fix," Genereaux said.

Lisa is a business reporter who covers the IT industry for the Salt Lake Tribune. She can be reached at lisac@sltrib.com.

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Filling Silicon Valley's Appetite for Programmers

Paula Harris

The hub of software development once defined as "Silicon Valley" is steadily mushrooming into the entire San Francisco Bay Area—from the small, upcoming companies in the city's South of Market area, to the large data centers in the East Bay, to the burgeoning telecommunications industry in the North Bay's Petaluma and beyond.

However, the local demand for high-caliber employees is much greater than the supply as technology is growing faster than the local talent pool. An Internet browse through Bay Area company job banks will reveal hundreds of positions open in the local high-tech arena.

Talented software engineers with experience developing web-enabled applications are in the shortest supply. Specifically, Internet applications raise a myriad of security and performance issues which challenge both the technologies and the engineer.

Java is currently the hottest programming language, particularly for developing these web-based applications (C++ is now playing a lesser role). In the backend database arena, Oracle is the predominant technology for distributed systems.

Cobol is in high demand to deal with the infamous Year 2000 conversion, and companies are exploring creative measures to retain programmers with mainframe/Cobol expertise.

Because the pay tends to be higher, there is a trend for contract consulting, but as companies realize they still need an infrastructure of talented people internally, stock options and wage increases are becoming common incentives.

Salary ranges for senior software engineers with only three years experience start around \$70,000 per year increasing to up to \$125,000 per year for highly specialized people. Con-

sultancy fees are rarely below \$75.00 per hour, which most Bay Area senior software engineers demand as a minimum.

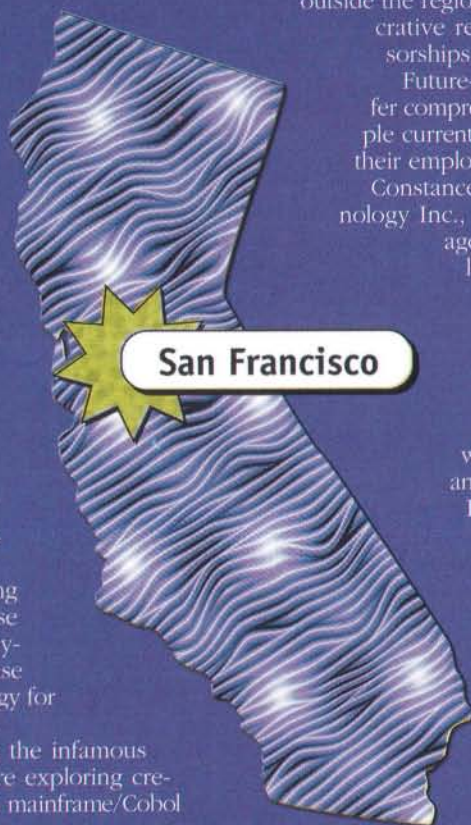
Still, many new employees have little loyalty to companies; "jumping ship" every year or less is a common occurrence. A number of companies are filling positions with people from outside the region and the U.S., luring employees with lucrative relocation packages including visa sponsorships.

Future-thinking companies are beginning to offer comprehensive education programs to keep people current with the technology in an effort to retain their employees.

Constance Grizzell, president of CastleRock Technology Inc., a Sausalito-based high-tech recruitment agency says employees are beginning to rank location on a par with salary. "In order of importance are first the actual work, second the company's culture, and third and fourth together are location and money," she says.

As the densely packed South Bay and East Bay become a commuter nightmare with limited affordable housing, employees and companies are looking toward the North Bay as a rural alternative. Companies and recruiters are successfully using the Wine Country lifestyle as a selling tool to bring new employees into "Silicon Vineyards."

In addition, even old school managers are starting to see the critical need to add flexibility into people's work schedules. Telecommuting from home or from satellite offices in suburban areas is common—even managers who previously had to be on-site are learning new technologies to manage remotely and build a sense of teamwork from afar.



Paula is a reporter for the Sonoma County Independent. She can be contacted at pkvella@aol.com.

Texas: The Sky's the Limit

Omar L. Gallaga

The exploding high-tech industry in Central Texas has created a huge demand for programmers in the area, one that isn't being met, experts said.

Austin and its surrounding areas are home to Dell, Motorola Semiconductor Products Sector, AMD, Tivoli, Dazel, and many other companies that are in constant need of workers who are skilled in C, Java, Visual Basic, and web programming skills that involve HTML and ActiveX.

Naomi Lyons Friedman, owner of Access Hi-Tech Austin, a consulting firm, got to know the market for programmers when she did job hunting for her husband, now a senior engineer at Symyx.

"There's a shortage of people who have all the right background and the right skills," Friedman said. "There's just not enough programmers to fill the slots that are out there."

The Greater Austin Chamber of Commerce and Austin Community College have taken measures similar to their efforts to build a chip industry workforce in the area. ACC has continued adding programming classes and the Chamber has tried to corral smaller software companies to join its efforts in workforce development.

Some companies have taken to hiring on nonprogrammers and putting them through intensive four-to-six month courses. Even local high schools have gotten into the act, expanding their curriculum to give students an early start toward high-tech careers. Despite those efforts, many companies are still recruiting workers from Silicon Valley, the northeast and from other countries. Brian Massey, a vice president at SoftReality Inc., said he's seen a lack of headhunters in the area and few ways for small firms to track down the skilled workers they need. "It seems like personal networks are the only way to track these people down. We see people coming out of the universities, especially the University of Texas, looking for \$40,000 a year with no experience."

Companies who are looking for programmers and the programmers who job hop have created a cottage industry in Austin. Small firms like Friedman's Access Hi-Tech, Austin's HireTech and several temporary staffing firms have thrived by putting together companies with hard-to-find technical workers.

Massey's companies, which does customized software development on an

outsource basis, looks for people with strong C and Windows skills. SoftReality also scouts out for programmers who know Visual Basic and database applications.

Corise Blair, executive director of the Austin Software Council, said the need for programmers extends to areas beyond software development. Chip companies and practically any firm that uses computers need workers with programming skills, she said.

"The computers companies are using now are so complicated, it very often takes a professional to keep the networks running and to keep programs they've designed running," she said. The demand is so large, programmers who have the right skillsets can name their asking price, Blair said.

"The sky's the limit for these workers," she said. "It's definitely an employee's market."

Omar is a technology reporter for the Austin American-Statesman. He can be contacted at ogallaga@statesman.com.



Austin

Phoenix: The Silicon Desert

Catherine Reagor

Phoenix, Arizona, recently garnered the nickname "the Silicon Desert" because of the many technology firms it has attracted in recent years. But with the city's record low unemployment rate of 2.5 percent, the term is also indicative of how dry the well is for employers in the city—especially information technology professionals and computer programmers.

"Phoenix's job market is so tight for technology workers that companies are escalating salaries and offering all types of perks to land skilled people," said Charlie Balchunas of the staffing firm Source Services. He went on to say that some Phoenix firms have had to expand their search into regions as far north as Canada just to find programmers.

As in other parts of the country, Phoenix technology firms are raising salaries and offering signing bonuses to attract the people they need, particularly to meet their computer needs for the problems the year 2000 will bring.

Graduates with associates degrees in computer information systems and electronics from DeVry Institute of Technology in Phoenix are being enticed with signing bonuses of as much as \$3500. ADFlex Solutions, a Phoenix-area circuit maker, pays its employees referral bonuses of \$150 for each person they recommend who is hired and stays with the company for 30 days. Another Phoenix firm, Microchip Technologies is paying signing bonuses of nearly 20 percent of a base salary. The company is expanding and adding another 2000 jobs at its Phoenix operations.

AG Communications Systems, which makes telecommunications equipment, opened a daycare center and a gym for employees and their families.

To draw computer programmers and other software and technology workers from California, Phoenix firms are matching the pay found in Silicon Valley. The average pay of a mainframe analyst in Phoenix is \$49,000 a year, compared to \$50,000 in San Jose, according to a national survey done by Source Consulting.

But the cost of living is much lower in Phoenix.

A computer programmer just out of school can expect to earn about \$37,000 in Phoenix. Escalating pay has caused some Phoenix technology firms to pause, but they have anted up to get the programmers, consultants, engineers, and systems managers needed to keep pace with the rest of the industry. Economists forecast that at least 5000 technology jobs including computer programming and development positions will be created in Arizona during the next few years.

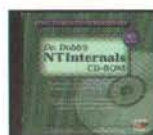
The state is one of the fastest growing in the country with a record number of firms growing and expanding there during the past several years. And many of those firms are clamoring for more information technology workers.

Catherine is a business reporter for The Arizona Republic and can be contacted at jcreagor@aol.com.



Phoenix

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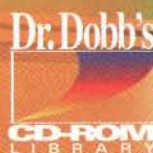
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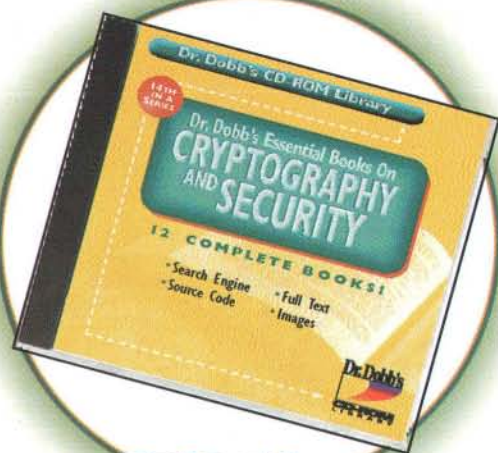
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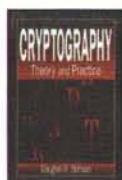
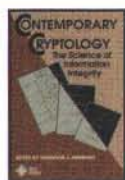
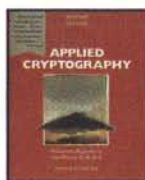
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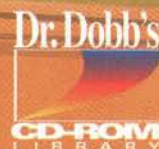
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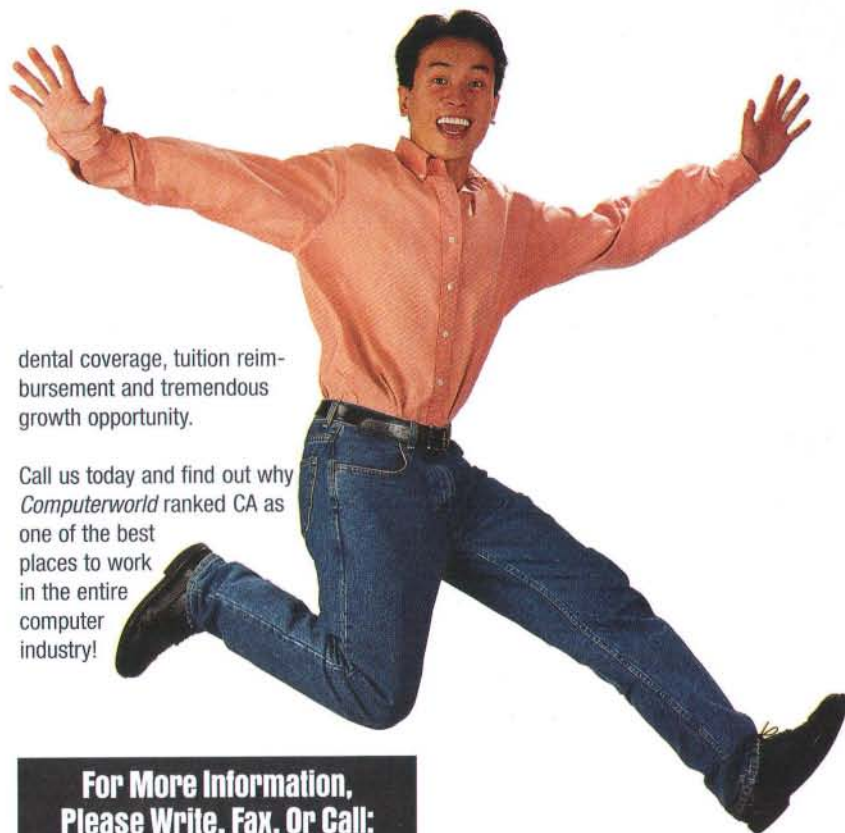
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Markus Zahn

Despite spending lots of time in classrooms, many students are still unsure of their abilities because they rarely get the opportunity to apply their training to real-world problems. One way to obtain practical experience is via part-time and summer jobs. Alternatively, many colleges and universities offer a more formal approach to integrating educational programs and work experiences, through internship programs that alternate on-campus classroom learning with mentored work opportunities. Depending on the program, students may earn academic credit or receive a paid salary. Students typically participate under the supervision of a company mentor and faculty member, and a written report (describing the work experiences) or similar academic effort often is required.

In this article, I'll describe the VI-A Internship Program at the Massachusetts Institute of Technology (MIT) Department of Electrical Engineering and Computer Science (EECS) — a cooperative work/study program with industry and government in continuous existence since 1917. Although the VI-A program is unique in many ways, it is, nevertheless, representative of internship programs at most universities. I'll describe the program from a unique perspective — both as an MIT EECS professor of electrical engineering who's been

director of the VI-A program since 1994, and as a VI-A student intern from 1965–68.

The MIT EECS VI-A Internship Program

Students studying electrical engineering and computer-science (Course VI) at MIT who participate in the VI-A Internship Program generally mix academic study at MIT with three summer terms and one fall or spring term of work at one of the participating industrial or governmental organizations (see Table 1). This educational plan gives students opportunities to relate the scientific and engineering principles they discuss in the classroom to current engineering problems in the industry. Students receive competitive salaries during their company assignments.

There are approximately 28 participating companies with 37 work sites for the VI-A students. On occasion, VI-A students have worked at foreign offices of VI-A companies. Each year, approximately 160 students apply for about 80 positions. Since the program lasts three years, after some small attrition, more than 200 students remain in the program, which is about 20 percent of all MIT EECS students. Approximately 4000 students have graduated from this program since its inception in 1917.

The primary motivations for joining VI-A include:

- Stimulating and challenging work opportunities with cutting-edge companies and state-of-the-art experience not easily otherwise available. Such work experiences provide direction and motivation to academic studies. Summer job hunting problems are solved.
- Academic credit is given for each work assignment with opportunities for ob-

taining engineering-design points, as well as fulfillment of advanced undergraduate project requirements for those obtaining a Bachelor of Science degree after four years. VI-A students are able to graduate with their class.

- Easier to obtain excellent thesis topics and to be paid for doing thesis research.
- Competitive salaries. In most cases a graduate fellowship or research assistantship can help finance educational costs.
- VI-A graduates entering the industry often receive higher starting salaries than non-VI-A students because recruiters count the four work assignments as prior work experience.
- Being part of a prestigious program of 81 years that has trained many important leaders in industry and universities. VI-A alumni include inventors, entrepreneurs, founders of their own companies, top executives of companies, one astronaut, and at least 126 academicians, including seven MIT faculty members.

Experiences as a VI-A Student, 1965–68

I was a member of the program from 1965–1968, receiving both Bachelor of Science and Master of Science degrees in Electrical Engineering in June 1968. I was a “co-op” student at Raytheon, working the first two assignments at the Raytheon Equipment Division (Wayland, Massachusetts) and the last two assignments at the Raytheon Research Division (Waltham, Massachusetts) where I performed research for my master's thesis (“Pulse Compression Using Bragg Scattering of Light by Ultrasonic Waves”). My thesis involved light scattered by a traveling acoustic wave,

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which produced an optical signal of considerably shorter duration than the input pulse width of a "chirped" acoustic wave with a great increase in signal to noise ratio. To do this research, some extremely bright, motivated, and kind professionals arranged for Raytheon to custom-build the required equipment.

My co-op experience, at that time the cutting edge in acousto-optic interactions, was beyond the quality and availability of on-campus research, and the co-op earnings also helped finance MIT educational costs. That research experience motivated me to become a better classroom student and to continue my education by completing the MIT doctoral program. Today, I am an MIT professor of electrical engineering in the general research area of electromagnetic interactions with media.

As director of the VI-A Internship Program, I try to match students and companies so that every student's work and research experience is of comparable quality, inspiration, and professional reward to my own. The knowledge and time willingly given by Raytheon mentors provided examples of professional excellence and conduct that are still worthy of emulation today.

The MIT EECS Program

The Internship Program leading to simultaneous bachelor's and master's degrees in five years provided a model for the entire EECS program to follow beginning in 1992. Today, the course requirements for internship students are essentially identical to noninternship students. (Additional information about MIT can be found at <http://web.mit.edu/>; on the MIT Department of Electrical Engineering and Computer Science at <http://www-eeecs.mit.edu/>; and on the MIT EECS VI-A Internship Program at <http://www-eeecs.mit.edu/via/index.html>.)

The focus of the undergraduate curricula is on the fundamental principles and models of the electrical and computer sciences. Engineering concentrations, laboratory subjects, independent projects, and research complement this preparation by introducing more specialized techniques of analysis, design, and experimentation in a variety of fields.

The department of electrical engineering and computer science offers programs lead-

ing to the master of engineering degree and to the bachelor of science degree. Three preprofessional four-year bachelor's programs are available: one designed for students specializing in electrical science and engineering (VI-1), a second for those specializing in computer science and engineering (VI-3), and a third for those whose interests cross this traditional boundary (VI-2). The principal department professional program leads directly, through a seamless five-year course of study, to the simultaneous awarding of the master of engineering and one of the three bachelor's degrees. An undergraduate who wishes to pursue the master of engineering degree initially registers for any of the three bachelor's programs. The VI-A internship program combines either the professional master of engineering or a preprofessional bachelor's academic program with periods of industrial practice at affiliated companies. A minor in biomedical engineering is also available.

The program leading to the master of engineering degree in electrical engineering and computer science is intended to provide the depth of knowledge and the skills needed for professional work as well as the breadth and perspective essential for engineering leadership in an increasingly complex technical world. This program builds on the General Institute Requirements in science (chemistry, physics, calculus, and biology) and the humanities. The additional requirements in EECS are four core courses that include laboratory components: structure and interpretation of computer programs, circuits and electronics, signals and systems, and computation structures; and three math courses including probability, mathematics for computer science, complex variables, and linear algebra. The heart of the program is a group of nine required Engineering Concentration subjects selected from seven concentration lists under constraints designed to ensure appropriate depth and breadth. The remainder of the program consists of restricted choices in engineering laboratories and mathe-

American International Group
Analog Devices Inc.
AT&T Labs-Research
Bankers Trust Co.
Bell Communications Research (Bellcore)
BBN Corp.
Communications Satellite Corp. (COMSAT Laboratories)
Digital Equipment Corp.
The Charles Stark Draper Laboratory
Hewlett-Packard Co.
Hughes Network Systems
IBM Corp.
InConcert Inc.
Jet Propulsion Laboratory
Lockheed Martin Infrared Imaging Systems
Lotus Development Corp.
Lucent Technologies (Bell Labs Innovations)
MIT Lincoln Laboratory
Motorola Inc. (Semiconductor Products)
PairGain Technologies Inc.
Rational Software Corp.
Qualcomm Inc.
SatCon Technology Corp.
Silicon Graphics Computer Systems
Silicon Valley Group Inc.
Teradyne Inc.
Texas Instruments Inc.
Xerox Corp. (PARC)

Table 1: Companies that participate in the MIT VI-A Internship Program.

matics that, together with free electives and a thesis, permit individual students to shape their programs to their special interests.

A focus on design is aided by two important components of the master of engineering program: laboratory-project subjects and a thesis. Laboratory-project subjects expose the student to the design of experiments, equipment, or computer programs, as well as to the problems of implementation and the evaluation of results.

The four-year preprofessional programs leading to a bachelor of science degree are shorter and less comprehensive than the master of engineering program. These programs are accredited by the Accreditation Board for engineering and Technology (ABET) and, in the case of VI-2 and VI-3, by the Computer Science Accreditation Board (CSAB). Recipients of a master of engineering degree normally receive a bachelor of science degree simultaneously. No thesis is explicitly required for the preprofessional bachelor of science degree. However, every program must include a major project experience at an advanced level, culminating in written and oral reports. Normally, the thesis for the master of engineering degree will fulfill this requirement for students receiving both degrees simultaneously. The requirements listed for the department programs are not rigid. Much flexibility is built into the elective structure; 60 units of totally unrestricted electives are included in every master of engineering program.

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(continued from page 20)

Programs leading to the professional five-year master of engineering degree or to the preprofessional four-year bachelor of science degrees can easily be arranged to be identical through the junior year. At the end of the junior year, most students will be offered the opportunity to continue through the five-year master's program; those students who are not selected may request reconsideration. To remain in the program and to receive the master of engineering degree, students will be expected to maintain a term rating of at least 4.0 (out of 5.0 overall) every term after the junior year. Admission to the master of engineering program is open only to undergraduate students who have completed their junior year in the Department of Electrical Engineering and Computer Science at MIT. Students with other preparations seeking master's level experience at MIT must be admitted to the master of science program.

The fifth year of study toward the master of engineering degree can be supported by a combination of personal funds, participation in the VI-A Internship Program, an award such as a National Science Foundation Fellowship, fellowship or traineeship awarded by MIT, graduate assistantship, or interest-free student loan. Assistantships require participation in research or teaching in the department or in one of the associated laboratories.

Five subjects from the list of engineering concentration subjects are required for bachelor's degrees:

- Students in Course VI-1 (bachelor of science in electrical science and engineering) must take the header subjects in each of the three Electrical Engineering Concentrations (communication, control, and signal processing; devices, circuits, and systems; and electrodynamics and energy systems).
- Students in Course VI-3 (bachelor of science in computer science and engineering) must take the header subjects in each of the three Computer Science Concentrations (artificial intelligence and applications; computer systems and architecture; and theoretical computer science).

- Students in Course VI-2 (bachelor of science in electrical engineering and computer science) must take the header subjects from any two of the Electrical Engineering Concentrations and any two of the Computer Science Concentrations. The fifth engineering concentration subject may come from any of the seven concentrations.

To receive the master's of engineering degree, a total of nine subjects from the lists of Engineering Concentrations is required: a Large Concentration consisting of a header and two other subjects from a single Engineering Concentration; two Small Concentrations, each consisting of a header and one other subject from a single Engineering Concentration; two additional concentration elective subjects, freely chosen from any of the seven Engineering Concentrations.

The Computer Science Engineering Concentrations are:

- Artificial Intelligence and Applications. This concentration is concerned with the use of computation to accomplish specific tasks that are complex and often only weakly defined. Attention necessarily focuses on subsets of these tasks for which useful solutions can be developed. Since problems in this area are often motivated by a desire to understand or emulate intelligent human behavior, there are strong links to other fields such as neuroscience, psychology, mechanical engineering, and linguistics.
- Computer Systems and Architecture. This concentration emphasizes the artifacts underlying computing systems such as machine architectures, networks, data management systems, and compilers. The problems studied are typically relatively well defined, and solutions are evaluated according to many criteria, including performance, cost, and completeness. Many subjects emphasize design and optimization issues and the definition of interfaces.
- Theoretical Computer Science. This concentration is characterized by the use of mathematics to better understand computation. The subarea of complexity the-

ory studies the limits and capabilities of various models of computation, as well as the relationships among models. In the subarea of algorithms, the efficient use of computational resources—such as time, memory, and the number of processors—is explored. The subarea of semantics studies the expressiveness of computer languages.

The Electrical Engineering Concentrations are:

- Devices, Circuits, and Control. This concentration concerns the application of electronics to the tasks of signal processing and energy transduction, including synthesis and fabrication as well as analysis and modeling of components, networks, and systems. Examples include digital and analog circuits and systems; power electronics, D/A and A/D conversion; silicon and compound semiconductor physics, devices, and simulation; micromechanical sensors and actuators; quantum physics and devices; superconductivity.
- Electrodynamics and Energy Systems. This concentration concerns the applications of Maxwell's equations and the Lorentz force law to quasistatic and electrodynamic systems and media. Examples include power systems; rotating machinery; electromechanical actuators, sensors, and systems; dielectric physics and high-voltage engineering; electromagnetic wave theory; radio, microwave, and optical systems; electrodynamics of plasmas and fusion energy systems; lasers, nonlinear optical interactions, and optical information processing; and electrophysiological and electrochemical systems.
- Communication, Control, and Signal Processing. This concentration is concerned with fundamental issues in the design, modeling, identification, optimization, and control of stochastic and/or dynamic systems; and the analysis and synthesis of algorithms and systems that process signals or information. Related applications are of interest, such as optical and data-communication networks; processing of speech, image, radar, geophysical,

More than Money

Michael Sung

One of the most important experiences I've had while completing my bachelor's degree and starting a graduate program in electrical engineering and computer science at MIT has been my participation in the VI-A Internship Program. The VI-A program has given me a chance to explore a number of research topics and gain practical work experience at the same time. The work assignments were beyond the quality and scope of typical summer jobs, enabling me to expand my horizons and nurture my current interest in computer architecture.

I entered the VI-A program by working at Silicon Graphics (SGI), in Mountain View, California. I was one of two original MIT interns assigned to SGI when the company joined the VI-A program in 1995. In lieu of salary, SGI paid for my MIT tuition (\$11,550 per term for the 1997-98 academic year), in addition to a stipend (about \$6000 per term) as part of the VI-A Fellowship Program. This was great: SGI pays for my education, while I conduct my thesis research using world-class computing facilities. Other amenities included access to restricted computing facilities, internal training programs, and participation in technical conferences—not to mention health-club memberships and employee discounts.

The first summer, I worked under the architecture group at SGI's microprocessor division, Mips Technology Inc. (MTI)—the group responsible for high-level microprocessor architecture simulation and architectural innovations for next-generation processors. I worked on performance simulation of the R10000 chip—SGI's flagship microprocessor and one of the first superscalar, dynamic-execution processors. With my initial exposure to working in industry, I learned the intricacies of how a microprocessor-design company functions, as well as the general product cycle of a microprocessor in development. In academia, it is often possible to lose sight of practicality or implementability, focusing instead on research.

At SGI, I was allowed to choose any research area I was interested in, and then pair up with a manager with expertise in that field. I took advantage of this opportunity to explore new topics and broaden my experience. In fact, I switched divisions my second summer to work under the Advance Systems Division (ASD), where SGI developed its high-performance computing products.

oceanographic, and other signals; distributed and parallel computation; neural networks; power systems; aerospace systems and logistical systems.

The Bioelectrical Engineering Concentration applies engineering principles and tools to the understanding of living systems and to the design of technical devices whose specifications require some knowledge of the properties of living systems. Examples include the quantitative description of biological, physiological, or psychological systems, such as the circulatory, sensory, or skeletal systems, protein or genetic structures, speech and natural language; devices that improve the operation of pathological systems (pacemakers, sensory aids, artificial tissues, and so on); and systems that aid in the effective delivery of health care (imaging systems, medical decision aids).

At that time, SGI had just acquired Cray Research, and my manager acted as a liaison between SGI and Cray. It was interesting to see the integration of the two companies and the strategy of merging technologies for future projects. That summer, I worked on developing a novel benchmark suite to accurately characterize the performance of SGI's SMP Challenge and DSM Origin 2000 multiprocessor machines. I was surprised at the level of access I was given to the prototype DSM machines, the first distributed shared-memory multiprocessors. In fact, I had access to some of the most powerful computers available.

This year, I am back at MIT's Architecture Group, working on my thesis topic of simulating trace caches as possible high-bandwidth instruction fetching mechanisms. I returned to the Architecture Group because I was able to develop a more research-oriented project suitable as thesis material, instead of being part of a project development team. However, perhaps the most interesting experience from this assignment was not directly related to the research at all, but rather watching the company evolve. I joined the company right when SGI was entering the spotlight. Known as the "sexiest" new company in the industry, SGI had a fun atmosphere in which carnivals on campus and visits from celebrities such as Michael Jackson or Steven Spielberg were common. However, by the time my next assignment rolled around, SGI's growing pains as evolved into a larger company, were palpable, especially after the Cray acquisition where SGI doubled its workforce. The company's focus moved more toward stability and company profit instead of technological innovation. This past year, I have been in the unique position of watching the company go through major restructuring. I've seen project cancellations, layoffs, and even the resignation of the CEO. During my years here at SGI, the company grew from a startup-like company into the graphics and high-performance computing juggernaut it is today.

These insights will be useful in the future, whether I'm working for another company or starting my own. My VI-A experience was integral to my development as an engineer in the real world.

Michael is a graduate student in the MIT electrical engineering and computer science program. He can be contacted at darkman@it.edu.

VI-A Admission Requirements

Course VI sophomores and selected juniors, registered and in good standing, are eligible to apply for the VI-A Internship Program. To gain admission, each student must be selected by one of the participating companies after an interview. Students, in accepting admission to VI-A, agree to remain in the program with their selected company until graduation with a master of engineering degree, or with a bachelor's degree if not admitted to the master of engineering program. Release from this obligation is granted only under extenuating circumstances.

Students are usually selected for the program by the participating companies during the spring term of their sophomore year. At the end of the junior year, students who are in the program are informed of their admissibility to the five-year VI-A program leading to the master of engineering degree. It is expected that most VI-A students will

qualify and complete their studies in five years. Elective credit is given for the experience gained during company assignments, and counted toward the master of engineering degree.

Important issues that a student considers about a VI-A company include:

- Work environment, company administration.
- Quality of work assignment, freedom to select work assignments.
- Financial considerations.
- Ability to obtain thesis topics, find MIT thesis advisor.
- Living and transportation arrangements.
- Recreational, cultural, and social opportunities.

Early in the spring term a VI-A orientation is given by the director of the program to acquaint interested students with the

program and the procedures for joining. The participating companies and laboratories supply informational material, which is made available in the VI-A office. Prospective students are urged to carefully peruse this material as an aid to their choices of companies to interview. To further assist in

the selection process, both a Student Open House and a Company Open House are held prior to on-campus interviews where all applicants can talk with current VI-A students and company representatives.

Company representatives interview applicants on campus early in March. Appli-

cants must sign up for interviews ahead of time in the VI-A office. Offers to participate in VI-A are then extended by the companies following these interviews. Final decisions on joining VI-A, and with which company, are made by the selected applicants in consultation with the VI-A office.

The Intern Trail

Timothy Kniveton

Summer, 1994. I just finished my first year at Carnegie Mellon University. Eager to get some experience, I went to California and found a summer job at Tandem Computers performing bug fixes and product improvements for legacy networking code.

Although I had a great summer and learned a lot, I was a bit lonely. At the end of my internship, I decided to come back next year, but bring some friends along for the ride.

December 1994. Back in California for the Christmas holiday, I drove up and down Silicon Valley's route 101 in search of companies for my friends. I stopped at Sun, Tandem, Hewlett-Packard, and Silicon Graphics to find out information on recruiting practices and contacts to bring back and share with my pals at Carnegie Mellon.

Although I was reasonably sure I wanted to return to Tandem, my coworkers had talked about the hot technologies and amazing parties of SGI. So I sent my résumé to its college recruiting office as well. When SGI came to campus to interview, I signed up through CMU's Career Placement office for a slot.

Summer 1995. After interviewing on the phone with an SGI manager, I was offered a position in SGI's network hardware. I eagerly accepted, and one of my friends took my place at Tandem.

During that summer, I learned the Verilog hardware simulation language, and developed a testbed for an embedded MIPS processor. This testbed was used to simulate a multiport ATM card which later became part of SGI's product line.

In addition to the wealth of knowledge I picked up, SGI threw some amazing parties, one of which included Huey Lewis and The News. Michael Jackson also stopped by my building for a demo of SGI's media server product line.

Interested in this new technology, I wandered down the corridor near the end of August and spoke with a couple of people who pointed me to the director of the division. I talked with him for a bit, and became excited about the emerging technology he described to me.

Summer 1996. Though I originally thought it would be wise to work at a different company for diversity of experience, I called back that manager and ultimately ended up working in the Me-

diaBase video server group. The network troubleshooting tools I had developed in C, Perl, and HTML, ultimately became part of the product when it began shipping, and I learned a lot about software engineering, testing, bug fixing, and working in a group.

I also enjoyed the company of many more of my friends from school, as they learned how to get jobs in the Valley. We rented an apartment for the summer. At work, I got to know the university recruiting staff during some of the intern events they organized.

At the end of 1996, I was chatting with the manager of SGI's university recruitment who asked me what I wanted to do next year. I told him how I wanted to try something different, maybe even apply at a company where I could work abroad.

Not wanting to lose talent, he described some of SGI's foreign offices and urged me to give him my résumé so that he could forward it to the field.

Summer 1997. After a harrowing all-night flight, I was riding a train up the valley in western Switzerland headed to SGI's European Manufacturing facility. I was greeted at the train station by a cheerful employee, who proceeded to show me around the area, find my apartment, take me shopping, and otherwise help me get set up.

My horizons were certainly broadened. While immersed in a foreign culture, I could still see the core SGI values and style at work. One of my jobs was to develop UI modifications which gather board repair information, tools to extract that information from the manufacturing support database, and database code to present that information in report format.

Outside of work, I drove all around Switzerland on weekends, and visited France (I was 30 minutes from the border) and Italy.

My four years as a summer intern complemented my course and project work at Carnegie Mellon. I also benefitted greatly from the group project atmosphere and software engineering concepts, both of which were invaluable later in my college career when working on advanced projects. As I prepare to receive my master's degree, I look back on my internships with fondness and gratitude.

Timothy is a graduate student at Carnegie Mellon University, where he does research in Wireless and Mobile Networking. He recently received his M.S. in electrical and computer engineering. He can be contacted at tim@cmu.edu.

Every Week is Exam Week

Eric Jewart

Research Triangle Institute (RTI) is an independent, not-for-profit, research and development organization that focuses on meeting customers' needs with cutting-edge technologies. As a participant in Duke University's Computer Science Internship Program, I interned with RTI for eight months in 1997. While there, I was exposed to the entire process of developing new capabilities, marketing them, and applying them to meet customers' needs.

I was originally hired to implement a prototype Competitive Intelligence System (CIS), a web-based, client-server application implemented in Java. The CIS is designed to provide convenient, timely access to relevant business information for all of RTI's 1450 employees, who work in widely diversified areas. My job included working with an information specialist to specify information requirements and the user interface, designing the system, and actually writing all of the code for the prototype. The goal was not only to develop a system that would streamline and unify RTI's new business acquisition process, but also to develop a new capability that could be marketed to potential customers.

Shortly after work on the CIS was begun, the opportunity arose to design and implement a similar system for a public utility. I helped write a proposal and market the system to this customer. After we won the proposal I became the lead programmer on the new project. Thus, I gained experience in dealing with a serious customer who expects high-quality, on-time results. This pressure showed me how much truth there is in my boss's saying, "In the business world, every week is exam week."

The most valuable aspect of my internship was that I learned where my programming expertise fits into the scheme of things. I found that actually designing applications and writing code is just a small part of holding down a job. I also had to relate well with clients, communicate with coworkers, learn new skills on the fly, write and review proposals and contracts, manage my time to meet many unrelated and often unexpected constraints, and much more. The internship provided me with experience I would not have gained in school, and taught me what to expect after I graduate.

Eric is majoring in computer science and economics at Duke University and is online editor for the DukeEngineer magazine. He can be contacted at ecj@acpub.duke.edu.

Participating Companies

The industrial and governmental organizations participating in the VI-A Internship Program are selected by recommendations of the electrical engineering and computer science faculty. From time to time the list of participating companies is reviewed and companies are added or removed as dictated by the changing areas of emphasis in the department and the needs of the various companies.

Internship assignments are presently carried out at the companies and laboratories listed in Table 1. Taken together, these companies and laboratories cover a very broad spectrum of technology, including electronics, communications, control, computation, and instrumentation. They provide opportunities for firsthand experience in manufacturing, testing, design, development, research, technical planning, and administration.

Each VI-A company is assigned an advisor from the Electrical Engineering and Computer Science Department faculty. These advisors serve as liaisons between the campus and the participating companies. VI-A faculty advisors monitor the progress of their students on work assignments through visits to the company.

Each VI-A student carries out all VI-A assignments with a single company or laboratory. The technical level and responsibility of the assignments increase as the student gains experience. While working, students are subject to company regula-

tions and receive regular compensation for their work. They are not obligated to accept employment with the company upon completion of the program, nor is the company obliged to offer such employment; many do, however.

Degree Requirements

The master of engineering degree requirements for students in VI-A are, with minor exceptions, identical to those of non-VI-A students enrolled in the electrical engineering and computer science course. VI-A students must also complete four internship assignments for the simultaneous receipt of the bachelor of science and master of engineering degrees. If not admitted to the master of engineering program, a minimum of two internship assignments are required for the bachelor of science degree. Elective credit is earned for each term of practice, provided a VI-A student satisfactorily completes at least two internship assignments.

Leaving the VI-A program before completion is not a common occurrence, and is not undertaken lightly. At the time of joining the VI-A program, each student signs a "Student's Agreement to Participate," which states that by joining the VI-A program, the student is making a firm commitment to the VI-A company and to EECS to remain in VI-A until receipt of the master's of engineering degree if admitted to the master of engineering program, or of the bachelor's

of science degree if not admitted to the master's of engineering program. A student may not drop out of the VI-A program and if admitted to the master of engineering program must perform the master of engineering thesis research at the VI-A company. If the student experiences problems with the VI-A assignment, the student must inform the VI-A office and VI-A faculty advisor early so that corrective actions can be taken. Only under extraordinary circumstances and after the student, the VI-A office, and the VI-A company have exhausted attempts at finding a suitable assignment can a student make a request to the VI-A Director to leave the program.

Tuition Policy

VI-A students pay the regular two semester academic year MIT tuition. Many VI-A companies offer financial assistance during this term. Some offer their own programs, which may include funding a research assistantship or competitive salaries with full or partial tuition awards. Most companies participate in the MIT VI-A fellowship program where, in lieu of salary for one term, the VI-A fellowship program has the participating company fund a fellowship for a VI-A graduate student that pays one term's tuition, MIT student health insurance, and stipend that matches an on-campus research assistantship.

DDJ

The 1997 SANS Administration Security Salary

Careers for information technology professionals

Alan Paller

System administrators and security professionals hold critical jobs in information technology. They ensure that computer systems are continuously operational, that data is protected from both accidental and malicious loss, that users have easy access to the right programs and file systems, and increasingly, that World Wide Web sites are created, maintained, and secured. Their skill, perseverance, patience, and creativity directly impact the productivity of dozens, hundreds, and sometimes thousands of users in commercial, government, and educational organizations around the globe.

The salaries of system administrators and security professionals—especially those of the more experienced, higher-paid professionals—have been rising rapidly, due to a growing shortage of experienced system administrators. The average system administrator reported that

her/his salary increased by nearly 14 percent from 1996 to 1997. Those who earn above-average salaries are enjoying greater increases than lower-paid individuals. But even the average increase is far higher than the average increase in salaries for all IT professionals.

The Fourth Annual SANS Salary Survey, conducted by the SANS Institute (a research and educational organization that provides technical education for security and systems management professionals), reflects data from more than 1600 system administrators and security professionals who work in government (nine percent), universities and other educational institutions (18 percent), system integration (14 percent), commercial business processing (31 percent), and commercial research and engineering organizations (28 percent) in the U.S. and around the world. In this article, I'll present a subset of the salary survey. (For more of the survey results, go to <http://www.sans.org/>. To obtain more information about the SANS Institute, e-mail me at sans@clark.net.) Highlights of the salary survey include:

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professionals earn between \$30,000 and \$80,000. Sixty-one percent of system administrators and security professionals report 1997 salaries between \$40,000 and \$70,000 (see Table 1). The average salary is \$57,346.

- The average increase from 1996 to 1997 is 14.1 percent. System administrators and security professionals with substantially above-average salaries (over \$70,000) reported receiving percentage raises that were higher than the raises

Salary Range	Number of People	Percent
Under \$20,000	12	1
\$20,000–\$29,000	53	3
\$30,000–\$39,000	186	12
\$40,000–\$49,000	320	20
\$50,000–\$59,000	351	22
\$60,000–\$69,000	310	19
\$70,000–\$79,000	184	12
\$80,000–\$89,000	81	5
\$90,000–\$99,000	51	3
\$100,000 and over	49	3

Table 1: How much are system administrators and security professionals paid?

- The vast majority (86 percent) of all system administrators and security profes-

System and Survey

• System administrators and security professionals who manage Solaris, HP-UX, and AT&T UNIX systems report higher than average salaries. Those who manage Novell Netware systems report lower than average salaries.

received by lower-paid system administrators and security professionals.

- System integrators pay top salaries, followed by commercial organizations. Government and university salaries remained much lower than salaries in other organizations.
- California emerged again as the leader in the salary race, closely followed by the U.S. Northeast (NY, MD, CT, VT, PA, DE, ME, NH, CT, NJ, MA, RI) with the U.S. Southwest (NV, AZ, UT, NM, CO), U.S. South-central (TX, OK, AK, LA, MS, AL), and Asia following. Canada and Europe lag behind. Other areas surveyed include the U.S. Midwest (MI, IL, IN, OH, ND, SD, NE, KS, MO, WI, IA, MN), the U.S. Northwest (WA, OR, ID, MT, WY), and U.S. Southeast (KY, TN, VA, WV, FL, GA, SC, NC). (See Table 2.)

Region	Average Salary	Number
California	\$68,443	204
U.S. Northeast	\$61,818	430
U.S. Southwest	\$59,105	148
U.S. South-central	\$57,553	110
Asia	\$54,793	13
U.S. Midwest	\$54,660	230
U.S. Southeast	\$53,858	202
U.S. Northwest	\$53,257	76
Alaska and Hawaii	\$49,550	8
Australia	\$46,558	37
Canada	\$45,161	69
Europe	\$43,734	86
Africa	\$41,100	4
South America	\$36,243	10

Table 2: Does geographic region affect salary?

- The gender pay gap is still present, but continues to decline. The gap is smallest in government and largest in commercial organizations engaged in business processing.
- On average, those with master's degrees made salaries slightly above all other categories. (See Table 3.)
- The higher salaries for those with less than a year of experience reflect the enormous demand for experienced people. Companies are recruiting new system administrators and security professionals from other areas of information system, and are paying them well. The remainder of the data shows that each of the first few years of experiences account for approximately \$3000 in added salary.
- Seventy-three percent of system administrators and security professionals are responsible for managing more than three types of UNIX and Windows NT systems. There is little pay benefit to those who support more types.

average salaries. Those who manage Novell Netware systems report lower than average salaries.

- Consultants continue to make more money than salaried system administrators and security professionals.
- Several new reasons were reported for winning large salary increases, but the traditional reasons—switching employers, asking for a raise, and using comparative salary data—all showed up often.
- This year, for the first time, SANS asked system administrators and security professionals what their employers must do to keep qualified staff. The most commonly reported responses include: providing for training and technical conferences; paying fairly; recognizing employee contributions and ideas; and providing appropriate tools.

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	Some College	College	Masters Degree	
Women	\$48,039	\$53,910	\$60,827	
Men	\$57,770	\$56,960	\$60,671	
	Commercial Research	Commercial Business	Education	Government
Women	\$58,775	\$55,408	\$43,970	\$53,467
Men	\$62,278	\$59,066	\$46,684	\$53,575
				System Integrator
Women				\$61,649
Men				\$63,266

Table 3: How do education and type of organization affect the gender gap in salary?

Passing the C++ Test

Securing success in an interview

Al Stevens

In my August 1996 *Dr. Dobb's Journal* "C Programming" column, I reported that someone with two to five years experience programming C++ can, according to a report in *ComputerWorld*, command \$70,000 on either coast and \$65,000 in the central part of the country. The opportunities seem even better for programmers with Win32 programming experience, particularly Windows NT C++ and Microsoft Foundation Classes (MFC) programming experience.

Of course, no one expects the typical college graduate to have two or more years of solid experience programming a particular platform. The range of your experience depends on how your time was distributed between the usual class workload, lab time, research projects, and any part-time jobs you might have had. Nonetheless, there is a demand for qualified people and a shortage of qualified people. Employers will be looking to entry-level recent graduates to take up the slack. That's where you come in. You'll be competing with all those other grads

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for those jobs, and, if the *ComputerWorld* report is a forecast of what's coming, in two years, this summer's entry-level programmers will be the veterans knocking down those respectable salaries. The trick is to get your foot in the door now. Let's see if we can help prepare you to impress the folks who are interviewing new programmers.

Windows NT programming is Win32 programming, which, unless you are writing deep systems-level code, is the same thing as Windows 95 programming. If you don't have an NT system handy, latch onto a Windows 95 PC and a copy of Visual C++ 4.0 or later. I don't want you to neglect your studies these last few months—you have to get through finals before anyone talks to you about a job—but there are a few things you can do to prepare to demonstrate an understanding of the programming environments that employers want to discuss. That demonstration could be just the advantage that edges out the competition.

You need to show in a brief interview that you understand and can work with C++ in the Win32 development environment. Those are two different curves, both of which are steep. Let's start with C++.

I put together a list of questions that employers can ask potential programming employees to qualify them as to the extent of their C++ knowledge. These, I

think, are representative of the kinds of things that you will be asked. I published the questions and my opinions about appropriate answers in my column. From the response I got from readers, I learned that many practicing C++ programmers cannot answer some of these questions. The pop quiz, as one reader labeled it, sent many programmers back to their reference books. They had fallen into a rut, using a comfortable subset of the language, and, as a consequence, were not using C++ to its full potential. Other readers suggested more questions and a broader approach to qualifying an applicant. Those suggestions caused me to evaluate my approach and adjust it.

I divided applicants into three groups: those who understand C++ well enough to use it as an improved C; those who have experience designing C++ classes; and those who are so motivated that they keep up with the recently approved specification of standard C++.

I will state here that anyone who has read and understands my book, *Teach Yourself C++* (MIS Press, about to be released in its 5th edition), or who has completed the tutorials on *The Al Stevens Cram Course on C/C++* CD-ROM (available from *Dr. Dobb's Journal*), can ace all three parts of this quiz. If you consider that statement to be a shameless plug,

Dr. Dobb's Special Report, Spring 1998

then you fully understand my motives. It's true, nonetheless. Let's get on with it.

A lot of what follows was taken directly from my August and September 1996 "C Programming" columns in *Dr. Dobbs's Journal*. I reworded some of it to reflect your concerns and to incorporate some changes and corrections that other readers sent to me.

Questions for All C++ Applicants

Here's the first group of C++ questions and my opinions about what some acceptable answers would be. These questions do not cover C++ wall-to-wall, of course. I selected them as being typical of the kinds of things that all C++ programmers should be expected to know. There are five questions. Three correct answers is a good score.

Q: How do you link a C++ program to C functions?

A: By using the *extern "C"* linkage specification around the C function declarations.

You should know about mangled function names and type-safe linkages. Then you should explain how the *extern "C"* linkage specification statement turns that feature off during compilation so that the linker properly links function calls to C functions. Another acceptable answer is "I don't know. We never had to do that." Merely describing what a linker does would indicate to me that you do not understand the issue that underlies the question.

Q: Explain the scope resolution operator.

A: The scope resolution operator permits a program to reference an identifier in the global scope that has been hidden by another identifier with the same name in the local scope.

The answer can get complicated. It should start with "colon-colon," however. (Some readers had not heard the term, "scope resolution operator," but they knew what `::` means. You should know the formal names of such things so that you can understand all communication about them.) If you claim to be well into the design or use of classes that employ inheritance, you tend to address overriding vir-

tual function overrides to explicitly call a function higher in the hierarchy. That's good knowledge to demonstrate, but address your comments specifically to global scope resolution. Describe C++'s ability to override the particular C behavior where identifiers in the global scope are always hidden by similar identifiers in a local scope.

Q: What are the differences between a C++ *struct* and C++ *class*?

A: The default member and base class access specifiers are different.

This is one of the commonly misunderstood aspects of C++. Believe it or not, many programmers think that a C++ *struct* is just like a C *struct*, while a C++ *class* has inheritance, access specifiers, member functions, overloaded operators, and so on. Some of them have even written books about C++. Actually, the C++ *struct* has all the features of the *class*. The only differences are that a *struct* defaults to public member access and public base class inheritance, and a *class* defaults to the private access specifier and private base class inheritance. Getting this question wrong does not necessarily disqualify you because you will be in plenty of good company. Getting it right is a definite plus.

Q: How many ways are there to initialize an *int* with a constant?

A: Two.

There are two formats for initializers in C++ as shown in Example 1. Example 1(a) uses the traditional C notation, while Example 1(b) uses constructor notation. Many programmers do not know about the notation in Example 1(b), although they should certainly know about the first one. Many old-timer C programmers who made the switch to C++ never use the second idiom, although some wise heads of C++ profess to prefer it.

A reader wrote to tell me of two other ways, as shown in Examples 2(a) and 2(b), which made me think that maybe the answer could be extended even further to include the initialization of an *int* function parameter with a constant argument from the caller.

Q: How does throwing and catching exceptions differ from using *setjmp* and *longjmp*?

A: The throw operation calls the destructors for automatic objects instantiated since entry to the try block.

Exceptions are in the mainstream of C++ now, so most programmers, if they are familiar with *setjmp* and *longjmp*, should know the difference. Both idioms return a program from the nested depths of multiple function calls to a defined position higher in the program. The program stack is "unwound" so that the state of the program with respect to function calls and pushed arguments is restored as if the calls had not been made. C++ exception handling adds to that behavior the orderly calls to the destructors of automatic objects that were instantiated as the program proceeded from within the try block toward where the throw expression is evaluated.

It's okay to discuss the notational differences between the two idioms. Explain the syntax of try blocks, catch exception handlers, and throw expressions. Then specifically address what happens in a throw that does not happen in a *longjmp*. Your answer should reflect an understanding of the behavior described in the answer just given.

One valid reason for not knowing about exception handling is that your experience is exclusively with older C++ compilers that do not implement exception handling. I would prefer that you have at least heard of exception handling, though.

It is not unusual for C and C++ programmers to be unfamiliar with *setjmp/longjmp*. Those constructs are not particularly intuitive. A C programmer who has written recursive descent parsing algorithms will certainly be familiar with *setjmp/longjmp*. Others might not, and that's acceptable. In that case, you won't be able to discuss how *setjmp/longjmp* differs from C++ exception handling, but let the interview turn into a discussion of C++ exception handling in general. That conversation will reveal to the interviewer a lot about your overall understanding of C++.

Questions for Class Designers

The next group of questions explores your knowledge of class design. There are eight questions. Five out of eight is a good score.

Q: What is your reaction to this line of code?

```
delete this;
```

A: It's not a good practice.

A good programmer will insist that the statement is never to be used if the class is to be used by other programmers and instantiated as static, extern, or automatic objects. That much should be obvious.

The code has two built-in pitfalls. First, if it executes in a member function for an extern, static, or automatic object, the program will probably crash as soon as the delete statement executes. There is no portable way for an object to tell that it was instantiated on the heap, so the class cannot assert that its object is properly instantiated. Second, when an object commits suicide this way, the using program might not know about its demise. As far as the instantiating program is concerned, the object remains in scope and continues to exist even though the object did itself in. Subsequent dereferencing of the pointer can and usually does lead to disaster.

```
(a) int foo = 123;
```

```
(b) int bar(123);
```

Example 1: (a) Traditional C notation for initializers in C++; (b) constructor notation.

```
(a) class X {
    int anInt;
public:
    X() : anInt(10) {} // initializing int with a constant
};

(b) try {
    throw 10;
} catch (int anInt) {
    // initializing int by throw
}
```

Example 2: Alternative initialization notations.

A reader pointed out that a class can ensure that its objects are instantiated on the heap by making its destructor private. This idiom necessitates a kludgy *DeleteMe* kind of function because the instantiator cannot call the delete operator for objects of the class. The *DeleteMe* function would then use "delete this."

I got a lot of mail about this issue. Many programmers believe that *delete this* is a valid construct. In my experience, classes that use *delete this* when objects are instantiated by users usually spawn bugs related to the idiom, most often when a program dereferences a pointer to an object that has already deleted itself.

Q: What is a default constructor?

A: A constructor that has no arguments or one where all the arguments have default argument values.

If you don't code a default constructor, the compiler provides one if there are no other constructors. If you are going to instantiate an array of objects of the class, the class must have a default constructor.

Q: What is a conversion constructor?

A: A constructor that accepts one argument of a different type.

The compiler uses this idiom as one way to infer conversion rules for a class. A constructor with more than one argument and with default argument values can be interpreted by the compiler as a conversion constructor when the compiler is looking for an object of the type and sees an object of the type of the constructor's first argument.

Q: What is the difference between a copy constructor and an overloaded assignment operator?

A: A copy constructor constructs a new object by using the content of the argument object. An overloaded assignment operator assigns the contents of an existing object to another existing object of the same class.

First, you must know that a copy constructor is one that has only one argument, which is a reference to the same type as the constructor. The compiler invokes a copy constructor wherever it needs to make a copy of the object, for example to pass an argument by value. If you do not provide a copy constructor, the compiler creates a member-by-member copy constructor for you.

You can write overloaded assignment operators that take arguments of other classes, but that behavior is usually implemented with implicit conversion constructors. If you do not provide an overloaded assignment operator for the class, the compiler creates a default member-by-member assignment operator.

This discussion is a good place to get into why classes need copy constructors and overloaded assignment operators. By discussing the requirements with respect to data member pointers that point to dynamically allocated resources, you demonstrate a good grasp of the problem.

Q: When should you use multiple inheritance?

A: There are three acceptable answers: "Never," "Rarely," and "When the problem domain cannot be accurately modeled any other way."

There are some famous C++ pundits and luminaries who disagree with that third answer, so be careful.

Let's digress to consider this issue lest your interview turn into a religious debate. Consider an *Asset* class, *Building* class, *Vehicle* class, and *CompanyCar* class. All company cars are vehicles. Some company cars are assets because the organizations own them. Others might be leased. Not all assets are vehicles. Money accounts are assets. Real-estate holdings

are assets. Some real-estate holdings are buildings. Not all buildings are assets. Ad infinitum. When you diagram these relationships, it becomes apparent that multiple inheritance is an intuitive way to model this common problem domain. You should understand, however, that multiple inheritance, like a chainsaw, is a useful tool that has its perils, needs respect, and is best avoided except when nothing else will do. Stress this understanding because your interviewer might share the common bias against multiple inheritance that many object-oriented designers hold.

Q: What is a virtual destructor?

A: The simple answer is that a virtual destructor is one that is declared with the *virtual* attribute.

The behavior of a virtual destructor is what is important. If you destroy an object through a pointer or reference to a base class, and the base-class destructor is not virtual, the derived-class destructors are not executed, and the destruction might not be complete.

Q: Explain the IS-A and HAS-A class relationships. How would you implement each in a class design?

A: A specialized class "is a" specialization of another class and, therefore, has the IS-A relationship with the other class. An *Employee* IS-A *Person*. This relationship is best implemented with inheritance. *Employee* is derived from *Person*. A class may have an instance of another class. For example, an *Employee* "has a" *Salary*, therefore the *Employee* class has the HAS-A re-

lationship with the *Salary* class. This relationship is best implemented by embedding an object of the *Salary* class in the *Employee* class.

The answer to this question reveals whether you have an understanding of the fundamentals of object-oriented design, which is important to reliable class design.

There are other relationships. The USES-A relationship is when one class uses the services of another. The *Employee* class uses an object (*cout*) of the *ostream* class to display the employee's name onscreen, for example. But if you get IS-A and HAS-A right, you usually don't need to go any further.

Q: When is a template a better solution than a base class?

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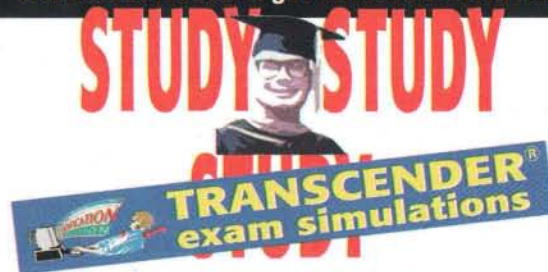
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A: When you are designing a generic class to contain or otherwise manage objects of other types, when the format and behavior of those other types are unimportant to their containment or management, and particularly when those other types are unknown (thus the genericity) to the designer of the container or manager class.

Prior to templates, you had to use inheritance; your design might include a generic *List* container class and an application-specific *Employee* class. To put employees in a list, a *ListedEmployee* class is multiply derived (contrived) from the *Employee* and *List* classes. These solutions were unwieldy and error-prone. Templates solved that problem.

Questions for ANSI-Knowledgeable Applicants

There are six questions for those who profess knowledge of the progress of the ANSI committee. If you claim to have that much interest in the language, you should know the answers to all these questions.

Q: What is a mutable member?

A: One that can be modified by the class even when the object of the class or the member function doing the modification is *const*.

Understanding this requirement implies an understanding of C++ *const*, which many programmers do not have. I have seen large class designs that do not employ the *const* qualifier anywhere. Some of those designs are my own early C++ efforts. One author suggests that some programmers find *const* to be such a bother that it is easier to ignore *const* than to try to use it meaningfully. No wonder many programmers don't understand the power and implications of *const*. Someone who claims to have enough interest in the language and its evolution to keep pace with the ANSI deliberations should not be ignorant of *const*, however.

Q: What is an explicit constructor?

A: A conversion constructor declared with the *explicit* keyword. The compiler does not use an explicit constructor to implement an implied conversion of types. Its

purpose is reserved explicitly for construction.

Q: What is the Standard Template Library?

A: A library of container templates approved by the ANSI committee for inclusion in the standard C++ specification.

An applicant who then launches into a discussion of the generic programming model, iterators, allocators, algorithms, and such, has a higher than average understanding of the new technology that STL brings to C++ programming.

Q: Describe run-time type identification.

A: The ability to determine at run time the type of an object by using the *typeid* operator or the *dynamic_cast* operator.

Q: What problem does the namespace feature solve?

A: Multiple providers of libraries might use common global identifiers causing a name collision when an application tries to link with two or more such libraries. The namespace feature surrounds a library's external declarations with a unique namespace that eliminates the potential for those collisions.

This solution assumes that two library vendors don't use the same namespace, of course.

Q: Are there any new intrinsic (built-in) data types?

A: Yes. The ANSI committee added the *bool* intrinsic type and its true and false value keywords and the *wchar_t* data type to support character sets wider than eight bits.

Other apparent new types (*string*, *complex*, and so forth) are implemented as classes in the Standard C++ Library rather than as intrinsic types.

In my original column, I left out *wchar_t* even though I should have known about it. Several readers wrote to correct me. I tell you this now to emphasize that even I would not have scored 100 percent on my own test.

Understanding Win32

I haven't put together a list of questions that you should know about the Win32

API because the subject is way too broad to cover that way. There's no way that I could guess what an interviewer is likely to ask. Instead, I'm going to tell you how to become expert enough to get through an interview. You'll have to cram this work into your otherwise busy student's schedule. I don't know how to tell you where to find the time, but if you can do it, it's worth it. Forsake the social life for the next several months. Try to get by without sleeping. (It's easy. You do all the things you would otherwise do, but you do them tired.) You are investing in your future, and this might be the most profitable time you'll ever spend. Don't, of course, neglect your other studies.

You'll need a Windows 95 (or NT) system with Visual C++. Run the tutorials that the VC++ online books include. Get comfortable with the programming environment—the editor, the debugger, the online documentation, the class wizard, the resource editor, and so on.

Next, you need two good books about Windows and MFC programming. These books are the classic *Programming Windows 95*, by Charles Petzold, and *Programming Windows 95 with MFC*, by Jeff Prosise (both published by Microsoft Press). Read the Petzold book cover to cover. Do it at your computer and run the programs that Charles includes. Step through them with the VC++ debugger. Get a solid foundation in the Win32 API, the Windows event-driven, message-based programming model, and the Windows way of using resources—menus, dialog boxes, controls, and so on.

Now, read Prosise. Learn the MFC application/document/view architecture. Learn how the MFC class library encapsulates those things and the Windows resources. Run all of Jeff's programs with the debugger just as you did Charles's. Be aware that the debugger steps into all the MFC code. If you find yourself in the depths of an MFC constructor, for example, use the "Step out of" command to get back to the example. Eventually you'll learn to anticipate that and step over statements that would lead you into the vapor.

Here's the best advice I can give you. With both these books, when you are running the example programs through the

debugger, never step out of a line of code until you fully understand what the line of code is doing and why. If the book is unclear about it, and if, after wracking your brain and exhausting all your resources, you can't figure it out, send me a message at astevens@ddj.com. If I can't figure it out, I'll find someone who can.

This offer is good until December 24, 1999. If you don't have a job by then, you can have mine, because that's when I plan to get out of this business to avoid the Year 2000 fiasco.

How to Comport Yourself in the Interview

Bear with me now while I patronize you for a moment. I've sat through enough interviews to know what rings the chimes of an interviewer and what turns them cold. This is going to be like one of those motivational speeches that people buy on cassettes from late night TV pitchmen. Inasmuch as you already paid for the magazine, consider this one to be free.

Remember, no one expects you to demonstrate the breadth of experience and judgement that comes with years of experience. You should not be expected to know the relative merits of every compiler, operating system, application framework, and so on. You should know what those things are, and, being a smart young person, you are expected to have and voice strong opinions based on your limited experience, but those opinions need not demonstrate anything more than the youthful exuberance and enthusiasm to which you are naturally entitled. You are bullet-proof, beer is food, and all's right with the world.

Relax in the interview and be yourself. It is not an adversarial situation. The company really wants you to be the one. Most of us hate interviewing and hope above hope that the right person shows up in the first session so we can get out of having to do any more interviews.

Above all, don't pretend to know more than you do. Be truthful when you do not know an answer. Don't try to guess what the interviewer wants to hear. Don't be afraid to ask, "What are you getting at?" Tell the interviewer that, given the chance, you can learn whatever you lack in plenty of time to be of useful service to the

company. Most programming is intuitive to someone like yourself who has the aptitude. Make them know that you understand that concept and can apply it. The successful applicant is assured and confident. Make the interviewer feel that by hiring you, the company will solve its programming problems.

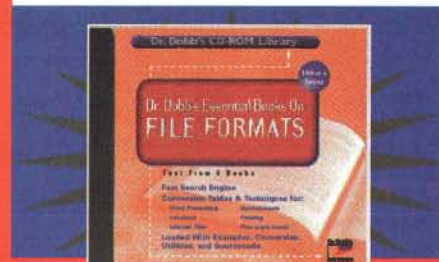
Here's what else not to do. I know I just told you to be yourself, but, please, avoid making social and political statements with your appearance. You have no way of knowing what the interviewer's biases and prejudices are, and that's the person whose muster you must pass today, even if on the job you'd never see that person again. Sometimes the initial screening is done by personnel types who wouldn't know a byte if it bit them. Dress and groom yourself neatly and neutrally. Try to look capable and professional. You can retreat to your own style, slob or fop, after you get the job and prove your worth.

Express a willingness to relocate anywhere and work long hours on any kind of application. Insist, however, that you want to design programs and write code. You are not a typist, shipping clerk, computer operator, data-entry person, manual writer, coffee maker, driver, gopher, or tech-support phone person. Those are fine professions, but not for you. You are a programmer. That's what you do best and that's what they need most. Emphasize that you want to work with the best technical people that the company has so that you can learn. Interviewers like to hear that.

Finally, don't get discouraged. You won't get an offer for every interview, and you'll get some offers that are unacceptable. Keep your spirits up, apply for every job that looks appealing, and spend your evenings sharpening your programming skills at home. If you see a job that you want, don't be dissuaded by an imposing list of qualifications that you do not possess. Chances are, the company won't find anyone with all the right skills anyway. Go for it and convince the interviewers that you can learn what you need to know.

Do these things and the right job will find you.

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Ilana DeBare

American companies will have to draft a virtual army of programmers to solve their Year 2000 problems. And they're recruiting soldiers for this army from both near and far—as near as the ranks of their own retirees, and as far as the universities of India.

Experts predict that it will take 300,000 to 500,000 programmers to handle all of this country's Year 2000 conversion work—the equivalent of one-quarter of America's software workforce.

The challenge isn't just finding enough programmers. It's finding programmers with skills in "legacy" languages—old mainframe computer languages such as Cobol.

Firms Scrambling

Companies are scrambling in a number of directions to get the people they need:

- Pulling their own computer experts off other projects to do Year 2000 work.
- Luring 70-year-old mainframe programmers out of retirement.
- Using promises of \$30,000 bonuses or 30 percent raises to steal each other's Year 2000 staff.

Ilana DeBare is a staff writer for the San Francisco Chronicle, in which this article first appeared. © San Francisco Chronicle (1998). Reprinted with permission.

- Shipping some of the work offshore—mostly to India, where one consulting firm has a 2000-worker "Year 2000 factory."

"The people are tough to find," said Lisa Donetti, western regional recruiter for Data Dimensions, a consulting firm in Bellevue, Washington, that works on Year 2000 problems. "Most of the people I recruit have 20 years in mainframes. The younger kids don't have these skills."

Sweet Vindication

For many legacy programmers, the current clamor for their services is sweet vindication.

"It feels good to be in demand again," said Dick Barnes, 58, a San Jose, California, Cobol programmer who is doing Year 2000 work for an Orinda, California, consulting firm called Systems Partners.

"We were just dirt at the bottom of the barrel a few years ago," said another veteran Cobol programmer who lives in Fremont, California. "Now we're kind of smiling and saying, 'See? Mainframe ain't dead yet.'"

While the market for people with Year 2000 skills is already hot, it's likely to get even hotter over the next year, experts say.

Salaries Rising

"The peak staffing demands will start to occur in late 1998 or '99," said Howard Rubin, a computer-science professor at

Hunter College in New York. "No one's hit the crunch yet, which is when companies will need people to start testing their Year 2000 solutions."

Salaries for Year 2000 programmers haven't hit the astronomic levels of \$100 an hour or more that some observers initially predicted.

But they've risen steadily—from about \$40 an hour to about \$60 an hour—and are likely to rise even higher before the year is out.

These salary increases pose a big retention challenge for companies that are trying to solve their Year 2000 problem entirely with their own in-house staff.

"One of my clients, a bank, had a great Year 2000 project manager who had been with them for 21 years," said Stephanie Moore, a consultant with Giga Information Group in Cambridge, Massachusetts. "She left for another firm that offered her two-and-a-half times her salary. She loved her old company, but she had kids in college. She couldn't pass the opportunity up."

Outside Consultants

So companies that don't want to lose their own Year 2000 staff are having to set aside big chunks of money for bonuses, raises, and other kinds of retention incentives. Prudential Securities, for instance, promises a \$30,000 bonus to Year 2000 workers who stay on board until January 31, 2000.

While some companies struggle to hold onto their own Year 2000 staff, others are

Driver's Seat

turning to outside consultants to handle the problem for them.

Some consulting firms are building their own labor pools from scratch. A Boston consulting firm called Keane Inc. trained 500 entry-level programmers in 1996—many of them former liberal arts majors who were eager to get into the lucrative world of high-tech.

Other Year 2000 consulting firms are bringing retired mainframe programmers back into the workforce. "This has been a change for me, since I hadn't had a supervisor since 1957," said Daniel Haagens, 72, a Cobol programmer who came out of semiretirement last year to work for a Year 2000 firm in San Jose called Matri-Digm. "I'd been working on my own or in technical management. But I'm enjoying this. I enjoy puzzles, and this is a different kind of puzzle."

Looking further afield, some consulting firms are using overseas programmers on Year 2000 jobs.

India Bound

While areas like Israel and Eastern Europe have gotten small amounts of this work, the bulk of it has gone to India.

"India has three major advantages," said Gopal Parandhamn, president of Global Solutions, a Sacramento, California, computer consulting firm with 80 employees in the United States and 50 in India. "It's got more scientists and engineers than any country after the U.S. It's an English-speaking country. And there's the cost differ-

*Year 2000
programmers today
are considering
more than raises and
bonuses*

ential, where pay is typically one-quarter of what it costs in the U.S."

Parandhamn says his Indian programming operation can expand to 300 workers if necessary to meet Year 2000 work orders.

Meanwhile, Tata Consultancy—the computer consulting arm of a big Indian corporation—opened a huge "Year 2000 Factory" in Madras in October. The facility, located in a former garment factory, will employ about 2000 programmers when fully staffed. "The time difference gives us extra leverage," said S. Sambamurthy, manager of Tata Consultancy's San Francisco office. "People can do project scoping here in the U.S. during the daytime, then pass it off to people offshore at night, and have the work done when they come back in the morning."

Like their American-born counterparts, India's mainframe programmers welcome the increased pay, prestige, and opportunity created by the Year 2000 problem.

But programmers in both countries are well aware that their moment in the driver's seat will be brief.

Some Year 2000 work will continue into the new century, as companies iron out glitches and get around to lower-priority date conversions. And companies will still need people for general maintenance of their legacy systems long after 2000.

Demand to Slacken

But at some point after the turn of the century, demand will slacken. So Year 2000 programmers today are considering more than raises and bonuses when they choose between jobs.

Fresno, California, programmer Jim Patterson got a 30 percent pay hike last October, when he moved from the computer consulting firm of Data Dimensions to one called Systems Partners.

But more important than the raise, he said, was the prospect of job security.

"Data Dimensions was concentrating solely on Year 2000, and it was not clear what there would be to do in the post-2000 environment," Patterson said. "With System Partners, Year 2000 is not its only focus. So there were visible post-2000 opportunities."

DDJ

Skills

Acquisition

Keeping pace with shifting technologies

Marian Corcoran

Programmers who want to update their skills generally fall into one of four categories. Those who:

- Perceive a new technology coming down the pike.
- Are needed for a project with a technology they don't yet know.
- See coworkers being laid off.
- Get laid off themselves.

There is a good chance that many of us are in the first category—programmers who keep our skills updated on a regular basis. Why? Well, for one thing, we like the challenge of a new technology, to see how it builds on the things of the past, and to make it do things we used to do with earlier technologies. There's a sense of excitement as we explore the latest in software development.

If you fall in the second category, you may find yourself needing to learn a lan-

Marian is CEO of the San Francisco Bay Area Center for Advanced Technology, and does consulting and training for companies worldwide in Java, C++, and Windows/ActiveX. She can be contacted at marian@centeradv.com.

guage such as C++ or Java in a week of intensive preparation for an upcoming project. Depending on your background and how quickly you learn, such mastery could be difficult and have serious consequences on your current position.

Clearly, we all want to avoid falling into the third or fourth category—watching our fellow workers get laid off, or worse, losing our own positions. If you do find yourself in one of the latter two categories, it's not too late to update your skills, but it is more difficult, due to the stresses that result from getting laid off.

If you do get laid off, are you likely to have difficulty finding a new job? I can hear you thinking right now, "But times are good. There is a shortage of programmers!" And I would answer, "Yes, that is true—this quarter." The truth, is our field is a volatile one.

Back in the days when people spent entire careers at one large company, you would not have had to worry about reeducation, because the company would take care of it for you. Now, more and more people work for smaller companies and hold several jobs over the span of their careers. I suspect that one reason for this shift is simply to keep pace with the rapid evolution of technology. Some people resent this shift away from lifetime positions and having to learn new skills.

Along with increased competition from global markets, this shift places a greater importance on taking charge of your own education, regardless of your personal situation. Your greatest assets are your skill set and your network of contacts.

Continuing Education Opportunities

Taking company-sponsored courses can be advantageous, since they cover the latest versions of the technology. These courses are usually week-long intensives, which is good if you are already familiar with some of the material and need to fill in the holes in your knowledge. The disadvantage is that you may have great difficulty absorbing the material if you've had no previous exposure to the field. In addition, the courses are expensive, usually somewhere between \$1500 and \$2000 per week. You might also have to travel for these courses, adding more expenses. However, I find that professionals who take these courses are usually reimbursed by their employers.

Many colleges and universities also offer continuing education courses. Students appreciate that these courses are taught in a weekly lecture by experienced teachers, with plenty of time between classes for students to absorb the material through homework and study. These courses usually cost less than company-sponsored

courses, since the universities are non-profit. As a result, extension or continuing education courses are a better option if you are trying to learn some fundamentally new concepts, and may not need to use them in your work right away. The disadvantage is that continuing education courses may require 10 to 12 hours per week of programming outside of class in addition to your work and family responsibilities.

Employers often will pay for courses from extension schools, generally requiring a grade of B or better for reimbursement. In my experience, about 75 percent of the students in these courses get reimbursed. One concern I have with these courses is that not all college instructors keep up to date. Because schools have limited funds, professors don't have the latest versions of software and may be forced to teach with older versions. And sometimes, the professor simply doesn't keep up. Some students report that the courses they took taught K&R C instead of ANSI C.

Special interest groups (SIGs) may also be a good place for you to continue your professional education. For example, the Object Developers Group in New York City (<http://www.objdev.org/>) offers seminars and study groups in C++, Java, and CORBA. The seminars are often taught by leaders in the field, and the topics are timely. These SIG meetings are usually free or very inexpensive, and they are also a good way to make contacts in the industry. I know people who have gotten job offers through contacts made from the SIGs. Seminars are helpful for a short introduction to a subject, but they are not a substitute for a full-fledged course.

Usenet groups are a good place to turn to if you are learning something and run across a problem. Many people have frequently asked questions (FAQs) that provide answers to some of the more esoteric aspects of a technology. If you are not comfortable asking a question on the group, you might consider writing to someone who posts to the group who has

Many universities across the country offer continuing education courses

a similar interest to yours. If you do post a question to a newsgroup, make sure you check the FAQ first to see if the question has already been answered.

Developing a Course Curriculum

How can an instructor create a course covering the latest topics, when technology is changing so quickly? This question is important for those of us teaching courses, as well as for the professional software engineer, because the techniques of keeping your skills up to date are the same. Furthermore, I believe that the students should be deeply involved in course development.

At the Center for Advanced Technology (<http://www.centeradv.com/>), students—all of whom are software specialists—have as much to say about what goes into the course as the instructors. For instance, I recently had to develop a course in Advanced Java Programming. What belongs in such a course? I worked with students and came up with several topics, including those in Table 1.

As a general rule, professionals prefer courses that introduce them to a number of topics. Once they know the basics, they can learn a topic in more depth when they use it. If you are studying on your own and want to know what is important, ask around—colleagues, friends, even on Usenet. In the list of topics for my Advanced Java course in Table 1, much of

the material is new. This presents the problem of finding information, as most of it has probably not reached books yet, or if you do find something in a book, it is most likely already out of date.

Today, I find it impossible to develop courses without the help of the World Wide Web, and you, as a professional pursuing continuing education, will also find the Web invaluable. For example, for updated material on Java, the JavaSoft site (<http://www.javasoft.com/>) is an invaluable source.

Much of the software and tutorial material for our Advanced Java course came from the "Products and APIs" section of the JavaSoft site. Sun has done outstanding work in making software available with good explanations of the concepts involved and "how to" material. For example, if you download software for Java and CORBA (under Java Interface Definition language) you will automatically get a folder called docs containing documentation, examples, and so on. This is true for each of the APIs. Going through this for all of the topics in such a course is time consuming, so instructors who do this for their students add a

Java Foundation Classes
Multithreading
RMI or Remote Method Invocation to use Java across distributed systems
JDBC or Java Database Connectivity to use Java to interface to databases such as Oracle or Access
Reflection
JavaBeans for component programming
Java and CORBA for distributed programming with Java and other languages
Security and Java Virtual Machine
Networking
Server and Servlets
Internationalization to prepare programs for use in different languages and areas

Table 1: Advanced Java Programming Course.

The San Francisco Bay Area Center for Advanced Technology

How do you set up an organization to further technology, assist software professionals in updating their skills, and reach out to the programmers of the future? At the San Francisco Bay Area Center for Advanced Technology (<http://www.centeradv.com/>), a training and consulting group, we have shaped our program by asking what professional programmers wanted. Here are some of the things programmers requested, and that we consequently offer.

- Programmers prefer overview style courses with multiple topics. Instead of Java GUIs in JFC, they wanted Java GUIs in JFC/AFC. Instead of separate

courses in OLE, ActiveX, COM/DCOM, they want those topics combined into one course.

- Workload can vary widely depending on where programmers are in the product development stage. Therefore, programmers want flexibility in "due dates" for assignments. Compassion for the stresses and demands in their lives is important
- Our students enjoy seminars with leading specialists, which we offer at no cost, as well as courses to examine the material in more detail and depth.
- Many of our students pay their own tuition, so, to keep the costs down, we

hold our classes in host companies such as Mentor Graphics or Lockheed Martin, who get free seats in exchange for using their facilities.

- Some feel a contribution to the technical community in the form of reaching out to young people of high school age will help the future. Only a small percent of the population can program, and most high school teachers do not have that ability. We are starting to work with such organizations as Plugged-In (<http://www.pluggedin.org/>) in East Palo Alto, California, to educate their teachers in the latest technologies.

—M.C.

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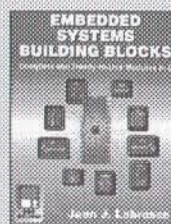
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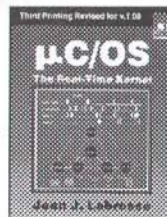
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(continued from page 37)

lot of value to the course and saves time for the students.

Innovative Approaches to Education

Some organizations are using innovative approaches to help software professionals keep their skills up-to-date. For example, while visiting a training professional in a company in Arizona, I was shown a room with many VCRs. The trainer had arranged for courses from all over the world to be taped so that members of the staff could study subjects not locally available. Members of his staff, especially those with families, could watch the tapes on their own time, rather than during rigid course times. As a learning tool, tapes have some advantages over

Marketable skills can keep you employed

live courses, since students can replay or pause the tape if there is something they don't understand.

Conclusion

I find that 90 percent of the students who take courses from the Center for Advanced Technology are not reimbursed by their companies. This concerns me, as the percentage of students who must now "pay their own way" is increasing. I am

concerned because I fear that as that trend continues, professionals will simply be unable to keep up. This could have serious ramifications not only for the region where I work (Silicon Valley), but nationwide as well.

Only two percent of the population has the ability to program. That makes us a special group, contributing in a unique way to the advancement of mankind with our gift. There are only 25,000 computer-science graduates per year. Silicon Valley alone has a shortage of 250,000 programmers. In response to such demand, many without degrees in the field move into software development. What we are calling "continuing" education is really "primary" education for many people.

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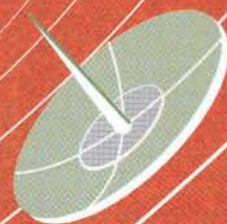
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How Will the Software Talent Shortage End?

It's a supply and demand problem

**Avron Barr and
Shirley Tessler**

Projections from all sources show a widening gap between supply and demand for software professionals. This shortage is worldwide, not limited to any specific technology (such as Java, SAP, or Year 2000 workers), and extends across all industries—not just high-tech.

A number of people we've talked to about the current shortage in skilled software labor argue that, while there may be short-term tightness in labor markets, these bottlenecks can't last very long in a free economy: Salary adjustments and other market forces will naturally balance the system by attracting more people into the

Avron and Shirley are principals of Aldo Ventures, a strategy consulting firm, and codirectors of the Software Research Team of the Stanford (University) Computer Industry Project. They can be contacted at <http://www-scip.stanford.edu/scip/> and at avron@aldo.com and tessler@aldo.com, respectively. A version of this article previously appeared in American Programmer.

field. Indeed, many people point to historical oversupplies of some scientific and engineering disciplines as a caution against pleas to introduce programs designed to increase the number of software developers. While we can't predict the future, we believe that a sustained software talent shortage would have serious ramifications.

Everyone agrees that there are only three ways this work-force shortage can end:

1. The supply of talented labor rapidly increases to catch up with rising demand, as a result of higher salaries, more new high-tech graduates, and so on.
2. New software development technologies are introduced, which increase the productivity of the existing labor force.
3. Demand for software slackens, and the slowly growing labor pool eventually catches up.

Economists, technologists, and other optimists are certain that either solution #1 or solution #2 will solve the talent shortage problem in short order. In our opinion, damage is already being done: Serious project risks presented by prolonged talent shortages lasting a decade or more

will eventually decrease demand for new systems to levels that can be reliably produced by existing talent supplies, which will continue to grow slowly.

The Blight at the End of the Tunnel

The shortage of software talent is caused, fundamentally, by increasing demand for software of all kinds: products from software publishers such as Microsoft, Oracle, and Sega (growing at 12–15 percent each year), corporate information systems from the back office to e-commerce (growing at 10–12 percent), and the embedded software in everything from automobiles to cellular phones to toys (for which there is no data on current size or growth). The broad use of increasingly complex software across so many industry sectors is both the reason for the shortage and the cause for concern—software has become critical to the economy.

Technologists and policymakers point to erroneous past projections of labor shortages in new technologies, such as the projection that telephone use would grow so large that every person in the U.S. would need to be employed as a telephone operator. They use the telephone operator metaphor to argue that

some imminent technical breakthrough will surely reduce the need for software specialists. While it is probable that new software development technologies will eventually appear, there are currently no new tools or techniques on the horizon that will significantly impact the productivity of software developers across broad classes of software. Furthermore, technology adoption is slow enough that even an easy-to-implement and integrate invention takes many years to penetrate even a small portion of the software industry. So, we are still left with a straightforward supply and demand situation for software.

We cannot be specific about what kind of software workers are most critically undersupplied. We believe that there is less of a problem finding entry-level programmers, but that the talent involved in successful software projects cannot always be found in entry-level recruits. Successful software development teams include systems analysts, systems architects, several types of designers, programmers of all sorts, testers, documentation writers, and even trainers. More importantly, successful projects require talent in project management and a number of other technical management specialties. We know that for all skills, the most talented are much more productive and less error prone than the average (a factor of 20 is often cited), and that experience and familiarity with the systems and types of systems they are working on increases productivity for all levels of talent in any job. But we don't know where the talent shortage is most critical, what skills are in most demand, or how entry-level workers match up with the talent levels and specific skills in short supply.

Some economists and government policy makers feel that increasing the supply of software people, by raising salaries and funding new educational programs, is the way to deal with the situation. After all, they argue, many current programmers had no formal training in computing and migrated to the profession from engineering or business or other fields. But software development has changed over the years: It is as complicated as any engineering task, and most people with a

*The shortage
of software talent
is caused,
fundamentally,
by increasing
demand for
software of all kinds*

talent for software are already doing it. Moreover, demand is growing fast, perhaps two hundred thousand unfilled new jobs a year in the U.S.; and increasing the supply of skilled workers is a slow process. Before significant progress can be made in expanding the trained labor force, many open positions will be filled with inexperienced people who have, on the average, lower productivity and possibly less training or talent in the various skill areas.

This "deskilling" of the software talent pool will eventually slow down the demand for software. Reduced demand seems like an unlikely prediction at a time when everyone owns a computer, every household device and toy has a chip in it, and corporations compete on the basis of Internet marketing schemes, supply chain management, and database marketing. But as software talent becomes scarce, systems built by less-experienced or less-trained teams may result in more-serious losses for many organizations than they already experience—delayed projects (like airports), abandoned projects (like the IRS revamp), and poor-quality systems (like air-traffic control). Disenchantment and pragmatic reassessment of how many systems their people can realistically deploy will make CEOs, CIOs, and

product designers rethink their investments in new projects. This situation is bad news for the software industry and for high-tech generally, but because so much of our national economic advantage is based on the rate of innovation we can achieve, slowing down the software race is also bad for the economy generally.

**Expanding the Supply
of Software Talent**

Of course, if we could quickly increase the supply of talent, we could eliminate this labor shortage in short order. Indeed, if anyone off the street could become a programmer tomorrow, there would be no shortage (and no welfare system). How much can the talent pool be expanded by education, immigration, and cross-over of intelligent people from other fields into software?

We believe that demand is growing much faster than the educational capacity of current institutions, which are disinclined to rapidly grow their capacity. (We have recommended the establishment of new, industry-funded trade schools, but see no likelihood that this will happen in the next decade.) Immigration in the current political climate is not a solution, and, in any case, the shortage is global.

Since entry-level people seem to be easier to find, some believe that software shops that insist on certain specific skills or experience levels are being too selective in their hiring practices. But talented programmers are much more productive than average developers, and they are rare. Furthermore, companies are reluctant to assign inexperienced people to mission-critical projects—they can slow things down and are more likely to make costly errors.

So it boils down to how many people already employed elsewhere will be attracted into software and how those people who do cross over (because salaries are rising, for instance) will impact the talent pool. Will they be, on average, as productive as the current work force? Not everyone has an aptitude for the various skills required in software: architecture, design, coding, debugging, project management, and so on. Developers at the low end of the talent curve can have a negative

impact on team productivity and software quality.

Even with substantial salary increases, software jobs will not attract an adequate number of people from other disciplines with real talent for the various development tasks because:

- The demographics don't look good. Future growth of the labor pool will be slowed by the retiring of the first generation of programmers. Changing workforce demographics, especially the increased percentage of women and minorities, is also problematic since these groups are historically less inclined than white males to enter engineering disciplines.
- There is a lot to learn before they can even start to contribute. Software development is an increasingly complex activity involving skills that take even the brightest, most talented people months to master. Software designers and architects must be familiar with a range of technologies and existing systems.
- Software development for the most part is still not a high-prestige position in most firms or in society at large, although that is changing slowly. Even among engineers (who are the most likely cross-over group), software people are looked down on as "not real engineers" because of the lack of maturity of the field as well as the historically low esteem of the software parts of engineering teams.
- Most software development work is not as attractive as it might first seem. It is characterized by tedious tasks and constant time pressure.
- The work is intolerant of errors, like the work of doctors and airline pilots, but without the perks. Both conceptually and detailwise, aspects of the work must be perfect.
- Most programmers are rarely appreciated for their work, except by their colleagues, and often chastised by management for their errors or their tardiness.

We are left with a situation in which the labor pool is expanding much more slowly than demand is growing. Firms are try-

Software is used in many ways to create business value

ing to find the talent they need for current projects by recruiting it away from other firms. To understand how this dynamic is evolving, it is helpful to segment the industry.

The Three-Tiered Software Industry

Software is used in many ways to create business value. In some sectors of the software industry, market forces are clearly already at work. Rising salaries are attracting top talent to meet rising production demand: talent from other sectors, from abroad, and from schools. At the top tier of software organizations are the venture capital funded software startups, the "boutique" software services firms, and the software publishing houses (see Figure 1). In this segment, where growth is nearly 15 percent, the operations of natural labor market forces is quite apparent. There are three things to note about this tier of the software industry:

- These firms were the last to feel pinch. Top salaries, opportunity to own equity, and stimulating work have drawn the

best software talent from other parts of the industry and an increasingly large portion of the best new graduates into these types of jobs. As a result, these firms did not feel any tightness in the labor market until recently. Therefore, dramatic salary increases, aggressive recruiting practices, and other market responses to the shortage are only beginning to appear there. We believe these will accelerate rapidly.

- It is apparent to CEOs and other executives in these firms that their survival depends on attracting top software talent. The need to produce innovative software of great complexity and high-quality as quickly as possible is a given—software is their bottom line.
- Furthermore, these companies are able to identify top talent and to offer the kinds of working environments that will attract the best software people. In fact, there is a radically different perception of software work in these firms from the working conditions in other companies that hire software talent.

Let's call these firms Tier 1 of the software industry. We believe this segment represents less than 10 percent of employment of professional software developers and produces only a fraction of the total business value attributable to software. Since growth in this tier has for several years involved migration of top talent from the rest of the software industry, we have found an increased awareness of the shortage elsewhere.

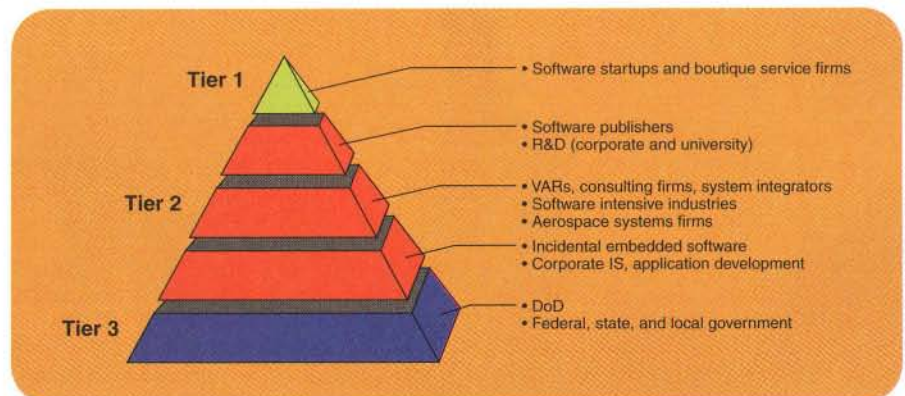


Figure 1: The three tiers of the software industry and corresponding sectors.

We divide the rest of the industry into two more tiers where the labor situation is quite different and where labor market forces have been much slower to operate. In Tier 2, which includes computer and other high-tech equipment manufacturers, communications companies and many firms in financial services and other information-technology-intensive industries, there is a growing realization that software development is critical to competitiveness. Some larger information technology (IT) services firms would be classified as Tier 1, others would have to fall in Tier 2. In Tier 3, which includes most manufacturing and government organizations, people who have realized the strategic importance of software have no choice but to leave—there is no executive-level awareness here about the key role of software and no chance of re-

Software has become critical to the economy

sponding to labor market changes even if the software's value were clearly recognized.

Labor Market Forces in Tier 2

Since there is no ability or will to deal with the talent shortage in Tier 3, and the Tier 1 firms have mostly figured out what they need to do to recruit and retain top talent, all the market dynamics take place in Tier

2. The firms in this category are beginning to realize the critical role of software in their industries, but are still hobbled by old attitudes, practices, and organizational structures. Their awareness of software's role in their business has moved beyond blaming software for delays in product launches and firing managers for failure to field new information systems. They realize that their products compete on the basis of software-enabled functionality and that their sustainable advantage in manufacturing, marketing, distribution, or sales is increasingly dependent on systems that require advanced software capabilities. However, these firms are unable to respond to labor market tightness as fluidly as those in Tier 1 because:

- Using the argument that IT is not a core competency of the business, these firms

Looking For A Career?

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responded to rising IT costs in the 1980s by dramatically reducing their IT staffs, disbursing their talented software employees to other parts of the software

industry, and in the process, sending a lingering message to those that stayed behind and to future recruits that software talent was not valued here.

Meeting the Demand

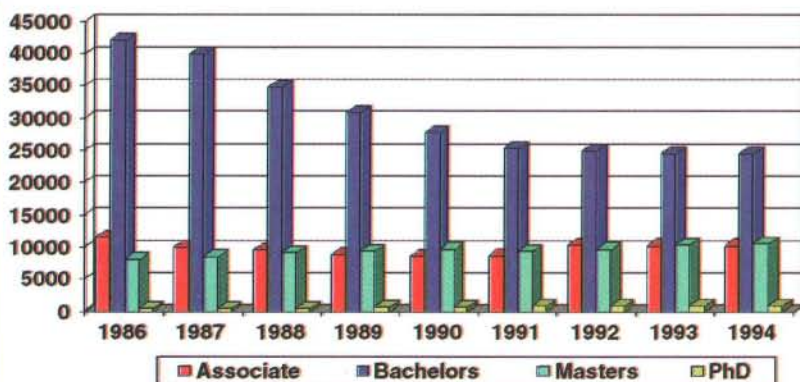
Studies such as a 1997 ITAA report estimate 190,000 open positions for software developers (excluding government and nonprofit organizations). The Gartner Group, on the other hand, is more pessimistic, estimating the shortage at 500,000 people. One 1994 study suggested that the supply of computer-science graduates in the U.S. is declining; see Figure 2.

By most estimates, there are about two million people developing software in the U.S., with demand growing about 15 percent annually. Factoring in an annual loss of perhaps 10,000 programmers who retire (a figure sure to increase after the year 2000), you find there are about 310,000 programming jobs open this year. By the year 2000, that figure should rise to about 415,000 positions available.

To meet this demand, U.S. universities will turn out about 46,000 computer-science graduates and 31,000 electrical

engineering graduates this year; some 8000 of these graduates are foreign students who will return home. In addition, there are approximately 20,000 MIS graduates and perhaps 30,000 permanent immigrants who will enter the U.S. programmer market. All in all, this translates into about 119,000 new programmers for the 310,000 open positions. By the year 2000, this figure should increase to about 184,000 new people, although, again, the demand will be for 415,000 programmers.

To a great extent, the problem of programmer supply and demand is nothing new. The rise in demand has been there for years, but the deficit has been masked by massive downsizing in MIS, aerospace/defense, and large computer firms, not to mention the simultaneous growth of software service exports from India. Software publishers have been the last to feel the pinch.



Source: Science and Engineering Indicators, 1996, 1997
Note: Associate degrees includes Math and CS

Figure 2: Computer science graduates in the U.S. 1986–1994.

- Software jobs in these firms typically are not high-prestige positions. (This attitude may be changing, but only at “cultural” speed.) The organizational status of software people reflects the historical introduction of information technology. In information systems, many software positions were recruited from the ranks of clerks when these organizations were formed in the ’60s. In engineering groups, software people also often have low-status for many reasons. While some firms are able to offer higher salaries for small, specially recruited teams of programmers, the majority of software-related positions are filled by whomever will accept the salaries offered.
- There are always people with credible software credentials who will take these Tier 2 jobs. Unfortunately, these firms have a hard time differentiating the truly talented from the pretenders. We contend that the most talented graduates, for example, are no longer even appearing in their recruitment process—they head directly for the high-paying and glamorous jobs in Tier 1. Managers with the technical background required to determine a recruit’s true talent have mostly left long ago for better positions. These firms are increasingly using IT services firms to outsource software development, but don’t necessarily have the talent in-house to then manage an outsourced project to a successful conclusion.
- The acceptance of less experience or talent keeps salaries down, but makes it hard to accomplish state-of-the-art systems, which in turn makes new recruits even less interested in signing up. While compensation is, of course, a factor in selecting a place to work, good software people also want to work with the newest technologies, produce innovative systems, and work with top-flight colleagues.
- Rather than change their practices to reflect the importance of software, these firms have tolerated massive losses—Standish Group data shows that 33 percent of projects are seriously delayed and/or over budget, and that another 40 percent of projects are abandoned completely.

As a result of these outdated attitudes and management practices, firms in Tier 2, in which the talent shortage has been apparent for many years, are still losing talent, still not raising salaries and changing working conditions adequately to recruit against Tier 1, are still indiscriminate about whom they hire, and still failing to make the decisions required to turn this situation around in order to retain the talent they have and recruit the talent they need.

In each industry, those few firms who use this human resource well will prevail. The others will eventually stop investing, frustrated with their inability to field effective IT solutions and initiatives. The results for high-technology firms and for the economy in general will be serious. The results for American programmers depend on where they are standing when the music stops.

What's the Solution?

Although it appears that there is no quick solution to the software talent shortage, there are concrete steps we can take to lessen the impact. One approach, of course, is to continue educating and re-training software people. We can also continue tapping the talent pool in other countries (although it is clear that there will not soon be another India). New software-development technologies (such as component-based software assembly) will help too. Employers will have to rethink how they approach the demand for software products and applications, what the necessary skills and job classifications are, and how they train their labor force.

One positive step that employers needing programmers could take is to establish industry-funded training (and re-training) programs in partnerships with schools. Industry might also begin more meaningful certification of some types of professionals. And clearly, research on software-development skills and technologies needs to continue.

Still, we are facing what appears to be a ten-year drought in the supply of software developers—and things will continue to get worse before they get better.

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D1013

Internet Job Se

Going online to find the right job

Brian D. Krueger

While the Internet has earned a well-deserved "Hype of the Year" title for all its media coverage, job searching has become established as one of the truly viable activities taking place on the Internet. While the rest of the world has only recently become aware of its existence, most colleges have been wired into the Internet for more than two decades, and most college students use its resources regularly. If you truly want to find a level playing field for your job search, the Internet is your stadium.

Web Sites

College Grad Job Hunter (my web site, <http://www.collegegrad.com/>) is the only site covered here that is designed as a "hub" site. It includes a job search forum, recent articles from my syndicated "Job Hunter" column, and job postings from some of the nation's largest employers. Additional information on such topics as résumés, cover letters, networking, interviewing, and offer negotiation are provided.

Online Career Center (<http://www.occ.com/>) provides one of the most comprehensive and usable employer databases and career information services on the Internet. You can keyword search all ads, or view them by industry, state, or city. OCC is sponsored by a nonprofit association of employers who are paying thousands of dollars to be listed, and you get free access. You can also post your résumé for free. Send your résumé in either text format or HTML format to

occ-resumes@occ.com with the subject line giving your one-line teaser about your background/summary/skills, and the text of your résumé in the body of the message. Your subject line is the first information that an employer will see, so make sure that it is enticing—but you must keep the subject line to 45 characters or less, so be specific. Your résumé will stay active in the OCC database for 90 days, although you can update it (and thus restart the 90-day clock) at any time. Each e-mail account is permitted only one résumé at any given time, so if your roommate uploads his résumé via your account, your résumé is history.

E-Span (<http://www.espan.com/>) provides a fully searchable job database with an interesting twist: You can enter your personal profile (including your educational level, years of experience, current job level, salary requirements, geographic areas desired, and job keywords). E-Span will then keep you posted on all new job opportunities added to the database that match your profile. Participating employers are given basically the same function in reverse: They can conduct a search against the résumé database, then post a job which will "troll" for new résumés as they are submitted. In addition to the Web, E-Span can be found on CompuServe, America Online, and Genie. Most of the online databases are updated once or twice per week, while the web site is updated continually. You can also upload your résumé for free directly to the E-Span ResumePro Database, where it can be viewed by interested employers. E-mail your résumé to resume@espan.com and use the subject line as the title for your résumé. You will be given a passcode (by return e-mail) that will allow you to view, edit, and delete your résumé so that you can keep it current.

CareerMosaic (<http://www.careermosaic.com/>), by Bernard Hodes Advertis-

ing, a leading employment advertising agency in the U.S., is a well-designed web site. The J.O.B.S. database is not as large as those of OCC and E-Span, but is certainly worth surfing through. CareerMosaic's Usenet Search allows you to search the multitude of national, regional, and local Usenet newsgroups for job postings. The front-end search engine, which allows for a combination of geographical and keyword searches, is the most intuitive front-end for Usenet search on the Web. CareerMosaic's International Gateway provides access to jobs in Canada, the United Kingdom, Japan, Hong Kong, and France. Its online ResumeCM form allows you to cut and paste your ASCII résumé for upload to the database. CareerMosaic also serves as home to some of the best employer jobs pages on the Web.

Monster Board (<http://www.monster.com/>) provides a cool interface with over 50,000 jobs. Keyword searching includes full Boolean capabilities. You can also submit your electronic résumé to the Resume On-Line section and surf through over 300 different employer profiles.

Jobtrak (<http://www.jobtrak.com/>) is an excellent source of job listings for college students and new alumni. Access is limited to participating schools, but most major universities participate. Jobtrak will provide you with information on how to get your school online for free. JobWeb (<http://www.jobweb.org/>) is sponsored by the National Association of Colleges and Employers (NACE) and provides a variety of entry-level job and employer listings, which you can search by keyword and geography or simply view in their entirety.

CareerPath (<http://www.careerpath.com/>) allows you to search help-wanted ads from major newspapers. It includes search capability by newspaper, job category, and keyword.

CareerPro's site (<http://www.flex.net/careerpro/>) is a good place to go if you

Brian is the author of the syndicated college newspaper column "Job Hunter" and College Grad Job Hunter (Quantum Leap Publishing, 1997), from which this article is adapted. Brian can be contacted at <http://www.collegegrad.com/>.

arch Strategies

are interested in developing an HTML résumé but lack the technical expertise. CareerPro will develop your HTML résumé for free and post it at its site (again, for free) for 21 days. Obviously, the hope is that you will continue to post (at a fee) beyond the initial free time frame, but there is no obligation to do so. Once the HTML format is developed, you can save the file for post at other sites, further extending your résumé's reach on the Internet. Send your résumé to fs-rock@firstsaga.com and CareerPro will respond with the URL of your new HTML résumé.

Before You Send E-mail

If you are going to compete in the world of cyberspace, take note: Students often unknowingly advertise their entry level job seeker status via their e-mail address. The ".edu" extension hanging off the end of an e-mail screams out entry level.

Consider spending a few extra bucks and getting hooked up with a local ISP for the duration of your job search. If you are going to do any serious searching online, it is best done with a ".com" or ".net" account. And you can usually have all your mail forwarded to one central account, thus avoiding the need to check multiple accounts.

Internet Résumés

Internet résumés are different from paper résumés. Most paper résumés are verb oriented. But Internet résumés need to accomplish a different purpose; they need to function well in a search. Employers do not search for verbs, they search for nouns. Nouns are the keywords or "buzzwords" that employers look for in prequalifying potential candidates.

In preparing your résumé for posting on the Internet, be sure to examine your résumé from the perspective of searchability. Even if the résumé is not initially keyword searched, it may find its way into

a database beyond its initial posting location. In constructing your Internet résumé, consider the view from the other side of the desk and what you would look for in searching for a candidate such as yourself. If the proper keywords are not already included, revamp your résumé and include a keyword section. If you initially formatted your résumé with a word processor, save it as ASCII text, then double-check all formatting.

Also, use an informative subject line. State your objective succinctly in 80 characters or less; use as many keywords as possible. But do not put the words "Entry Level" in the subject line. Few employers search the Internet looking specifically for entry-level applicants.

The standard for posting your résumé is ASCII text format, which generally allows for greater searchability. However, HTML is also growing in acceptance. The benefit of HTML is the flexibility with regard to graphics and overall presentation. When you create your own web site, you can post your fully formatted résumé, as well as a downloadable text version.

To understand Internet postings, it is important to note that there is more to posting your résumé than just placing it on a Usenet Newsgroup, then sitting back and waiting for the phone calls (or e-mails) inviting you to the interview. Although most "passive postings" such as this take little time to generate, they are also less likely to produce positive results. The best results are achieved through both passive and active posting.

When posting your résumé passively, you will have no idea who has viewed your résumé, when, where, how, or why. For all you know, your résumé was never viewed by anyone; or if it was, it may have been printed, reviewed, and entered into a database, while still producing no direct contact.

Active posting involves finding individual employer postings or job postings and responding directly with an e-mail résumé.

This is actually a much more productive method, since it is more direct and personal. It also provides you with the opportunity to add additional comments that relate to a specific employer, and a contact point for later follow-up.

When sending your résumé via e-mail, use one of these three formats:

- Text. This format is most appropriate for a résumé that you know will be scanned into a database.
- HTML. If you are certain that the recipient has an HTML-enabled mail program.
- Microsoft Word, the standard industry word processor. An employer that does not use Word will usually have a utility to convert from this format.

Web-Enabled Research

One of the most effective components on the Web is the proliferation of search engines that track the multitude of sites.

Using one of the search engines, gather information about a potential employer you have already identified (I like Yahoo! because the listings are submitted rather than robot detected, producing smaller, more-manageable search results). You can start with a search by company name. You will usually find the home page for the company you are searching for, as well as associated sites of suppliers or customers. Many companies maintain a listing of jobs at their site, so this is an excellent way to find out about current opportunities. Some companies also maintain an entry-level jobs page.

After you have gleaned the information you are seeking at the company site, back up to your search engine to expand your search. For example, if you are using Yahoo!, click on the category line under which the company name appears. This will expand out to a full listing of other companies in similar industries or touting a similar product line. Minimally, it will provide

you with a great deal of competitive information. Maximally, it may direct you to the up-and-comer in the industry, a company you may not have been aware of otherwise.

Back at the Yahoo! search-results page, click through to Alta Vista at the bottom of the page. This will greatly expand your listings based on your original search keywords. Alta Vista (maintained by Digital Equipment Corp.) is generally regarded as the best and cleanest of the robot sites. The results can sometimes be rather daunting (for example, you probably do not want to search

Alta Vista for "IBM"), but you will often find a wealth of information about the company, and commentary (both good and bad) about its reputation, product line, position within the industry, and so on.

After you have completed your employer name searches, return to Alta Vista (<http://www.altavista.digital.com/>) and perform a keyword search, just as you would at any job posting site. Why? Because this search will tap into all of the companies that maintain pages containing those keywords. Many of these pages will be job postings.

Keep in mind that you will likely come up with scores of personal résumé pages in the results of your search. Don't be discouraged by the number of others out there. In fact, use it as your inspiration to create your own HTML résumé. Remember, there are plenty of hiring managers (myself included) who are doing the exact same keyword search from the other side of the desk. I sift past the company sites to get to the personal résumé sites.

(a)

Atlanta, GA (atl.jobs)
Austin, TX (austin.jobs)
Baltimore, MD (balt.jobs)
Chicago, IL (chi.jobs)
Cleveland, OH (cle.jobs)
Columbus, OH (cmh.jobs)
Dallas-Fort Worth, TX (dfw.jobs)
Houston, TX (houston.jobs.offered)
Huntsville, AL (hsv.jobs)
Ithaca, NY (ithaca.jobs)
Las Vegas, NV (vegas.jobs)
Los Angeles, CA (la.jobs)
Long Island, NY (li.jobs)
Milwaukee, WI (milw.jobs)
New York, NY (nyc.jobs.offered)
Pittsburgh, PA (pgh.jobs.offered)
Philadelphia, PA (phl.jobs.offered)
St. Louis, MO (stl.jobs)
San Diego, CA (sdnet.jobs)
San Francisco Bay Area (ba.jobs.offered)
Seattle, WA (seattle.jobs.offered)

(b)

Arizona (az.jobs)
Florida (fl.jobs)
Illinois (il.jobs.offered)
Indiana (in.jobs)
Michigan (mi.jobs)
Minnesota (mn.jobs)
New England (ne.jobs)
New Jersey (nj.jobs)
New Mexico (nm.jobs)
North Carolina (triangle.jobs)
Ohio (oh.jobs)
Pennsylvania (pa.jobs.offered)
Texas (tx.jobs)
Washington, DC (dc.jobs)

(c)

Australia (aus.jobs)
Bermuda (bermuda.jobs.offered)
Canada (can.jobs)
Denmark (dk.jobs)
Europe (euro.jobs)
France (fr.jobs.offres)
Germany (de.markt.jobs)
Israel (israel.jobs.offered)
Ontario (ont.jobs)
Ottawa (ott.jobs)
Toronto (tor.jobs)
United Kingdom (uk.job)
South Africa (za.ads.jobs)

Table 1: geo.jobs newsgroups. (a) by cities; (b) by states; (c) international.

Usenet Newsgroups

The Usenet Newsgroups have been around much longer than the Web and continue to provide a forum for focused discussion and postings. Here are some of the best:

- biz.jobs.offered. The best Usenet newsgroups are also the most popular and contain mountains of data to sift through.
- misc.jobs.offered. The biz groups are designed more toward business interests, so misc tends to be a catchall of some of the more obscure job openings. But misc has been around the longest, so some continue to post here first.
- misc.jobs.offered.entry. The sole purpose of this newsgroup is to serve the entry-level job hunter.
- misc.jobs.resumes. This is the newsgroup to place your résumé with your own Usenet posting. Your résumé will either be purged or filtered by most browsers within less than one week, so diligence is the key to keeping your

résumé visible in this very popular newsgroup.

- geo.jobs newsgroups. No, that's not an Internet newsgroup location. The geo.jobs tag is short for geographical jobs newsgroups, of which there are quite a few, covering a diverse area nationally and internationally. They are great for those who are geographically focused on a particular city, state, or country. Table 1 provides an incomplete listing of what is available.

The SIG Posting Technique

Then again, who says you have to look for jobs where the online services want you to look for jobs? The best place to look for work is often directly where most of the online service action is—in the SIG (Special Interest Group) or Forum areas. While there are some very unique SIGs, there are also some that will tie in directly with your future career.

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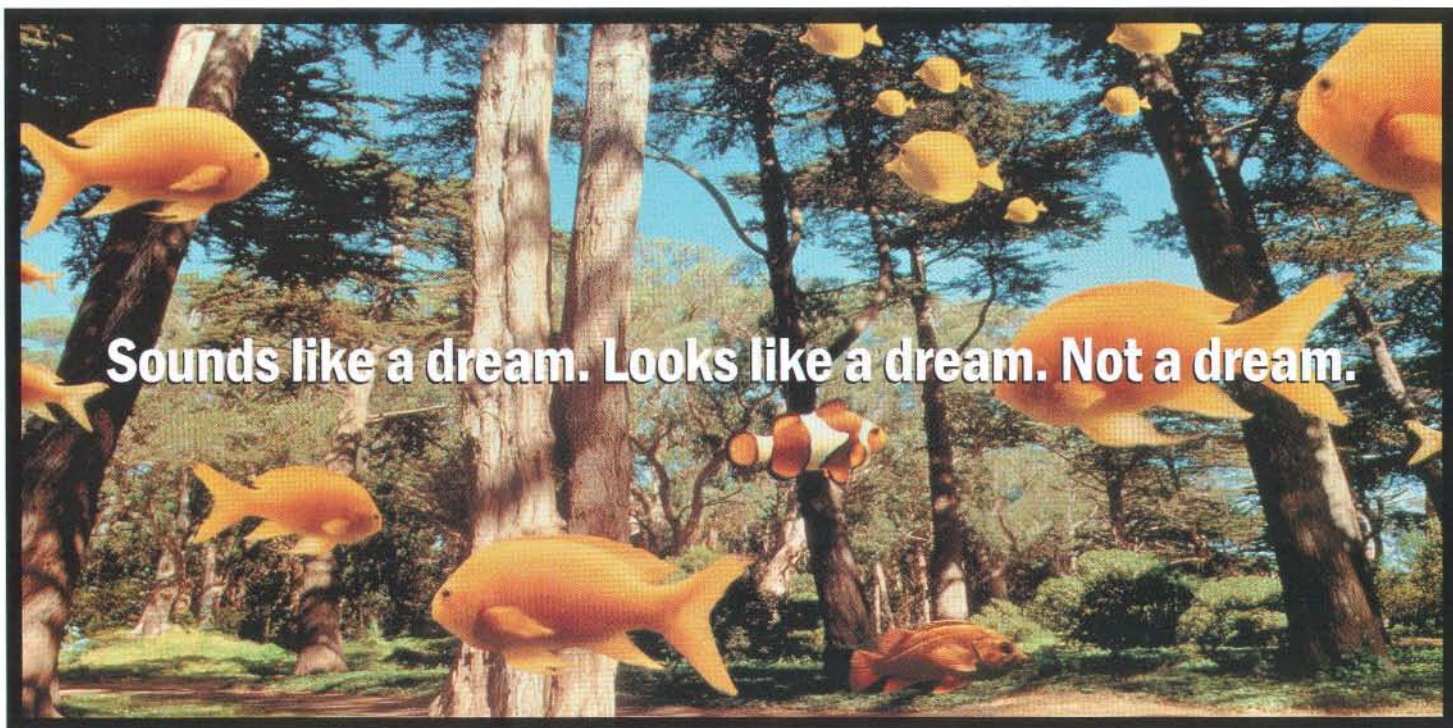
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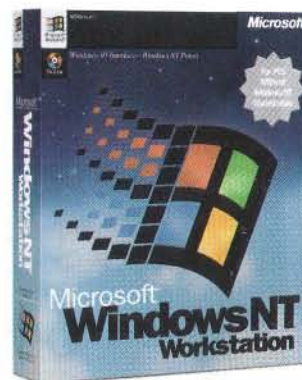
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